THE MIGRANT

A QUARTERLY JOURNAL
DEVOTED TO TENNESSEE BIRDS

PUBLISHED BY
THE TENNESSEE
ORNITHOLOGICAL
SOCIETY

JUNE 1998
VOL. 69, NO. 2

THE MIGRANT

A QUARTERLY JOURNAL OF ORNITHOLOGY

PUBLISHED BY

THE TENNESSEE ORNITHOLOGICAL SOCIETY

THE T.O.S. is a non-profit, educational, scientific, and conservation organization.

CURRENT DIRECTORY

(Revised May 1999)

EDITORIAL STAFF

Editor: J. Devereux Joslin, Jr., 112 Newcrest Lane, Oak Ridge, TN 37830 <jdjoslin@esper.com>
Assistant Editor: Charles P. Nicholson, Box 402, Norris, TN 37828
State Count Compiler: Christopher J. Welsh, 1400 Pine Springs Rd., Knoxville, TN 37922 <welsh@utk.edu>
Season Editor: Richard L. Knight, 804 North Hills Dr., Johnson City, TN 37604 <rKnight@preferred.com>
Regional Season Editors:
Western Coastal Plain: Martha G. Waldron, 1626 Yorkshire Dr., Memphis, TN 38119 <waldron@ten-nash.ten.k12.tn.us>
Highland Rim and Basin: Frank Fekel, 8612 Sawyer Brown Rd., Nashville, TN 37221 <fekel@coe.tnstate.edu>
Eastern Ridge and Valley: Richard L. Knight, 804 N. Hills. Rd., Johnson City, TN 37604 <rKnight@preferred.com>
Eastern Mountain: Richard P. Lewis, 407 V.I. Ranch Rd., Bristol, TN 37620 <vir@tricon.net>
Editorial Assistants:
Rebecca S. Robinson, 505 Ridge Rd., Maryville, TN 37803 <robinsonb@utk.edu>
Richard P. and Amanda Lewis, 407 V.I. Ranch Rd., Bristol, TN 37620 <vir@tricon.net>

OFFICERS FOR 1999 - 2001

President:	Chris A. Sloan, 1410 25th Ave., S., Apt. #610, Nashville, TN 37212
Vice Presidents:	East Tenn. - Ronald D. Hoff, 282 Hackworth Lane, Clinton, TN 37716
	Middle Tenn. - Hazel Cassel, 491 Hogan Rd., Nashville, TN 37220
	West Tenn. - Robert P. Ford, 319 River Bend Rd., Brownsville, TN 38012
Directors-at-Large:	East Tenn. - David Hassler, 1455 Hassler Rd., Byrdstown, TN 38549
	Middle Tenn. - Morris D. Williams, Rt. 5, Box 167, Lawrenceburg, TN 38464
	West Tenn. - Donna Ward, 220 Georgia Ave., McKenzie, TN 38201
Secretary:	O. Knox Martin, 1176 Dearing Rd., Memphis, TN 38117-6148
Treasurer:	David J. Trently, 1029 Morrow Rd., Knoxville, TN 37923
Curator:	Charles P. Nicholson, Box 402, Norris, TN 37828
Associate Curator:	N.P. McWhirter, III, 4962 Gwynne Rd., Memphis, TN 38117

Tennessee Warbler (TOS Newsletter) Editor: Theresa M. Graham, P.O. Box 366, Oakland, TN 38060, (901) 465-4263, Fax (901) 748-9200 <2graham@bellsouth.net>

Send subscriptions & address changes to:

Tennessee Ornithological Society

Box 10452, Knoxville, TN 37939-0452

Printed by: Russell Printing Options, 1800 Grand Ave., Knoxville, TN 37916

Copyright © 1999 by the Tennessee Ornithological Society — ISSN 0026-3575575

THE MIGRANT

Published by the Tennessee Ornithological Society
to Record and Encourage the Study of Birds in Tennessee.
Issued in March, June, September, and December.

VOL. 69 June 1998 NO. 2

The Migrant, 69 (2): 69-104, 1998.

REPRODUCTIVE BIOLOGY OF CAROLINA CHICKADEES

T. David Pitts
Department of Biological Sciences
University of Tennessee at Martin
Martin, TN 38238

ABSTRACT

During the 25 years of 1970-1972 and 1974-1995 I studied 214 nesting attempts by Carolina Chickadees (*Poecile carolinensis*) in artificial nest cavities in Obion and Weakley Counties, Tennessee. When given a choice of two sizes of nest cavities, chickadees selected the smaller cavity. Females typically laid eggs at the rate of one per day. Eggs averaged 15.60 mm in length and 12.05 mm in width. Clutch size ranged from 2-8, with a mean of 5.6; the most common clutch sizes were 6 (34.2% of the clutches) and 5 (29.2% of the clutches). The mean date of clutch initiation was 6 April; the first egg in the earliest clutch was laid on 11 March and the first egg in the latest clutch was laid on 28 May. Large clutches were laid early and, generally, small clutches were laid late in the nesting seasons. Nest cavity size did not significantly influence clutch size. Of 1164 eggs laid, 892 (76.6%) hatched, and 708 young fledged (60.8% of the eggs laid; 79.4% of the eggs that hatched).

One hundred fifty (70.1%) of the nesting attempts were successful, with a mean of 3.3 young fledged per nesting attempt and 4.7 young fledged per successful nesting attempt. Abandonment due to inclement weather, destruction by southern flying squirrels (*Glaucomys volans*), and usurpation by either Eastern Bluebirds (*Sialia sialis*) or House Sparrows (*Passer domesticus*) were responsible for many of the failures at the 64 (29.9%) nesting attempts that fledged

no young. Based on circumstantial evidence, some adult chickadees were killed at nest cavities by competitors such as House Sparrows, Tufted Titmice (*Baeolophus bicolor*), and Prothonotary Warblers (*Prothonataria citrea*). Eggs laid during the period 21 March-9 April were more likely to produce fledglings than were eggs laid either earlier or later.

Of the 100 nesting attempts where I identified either one or both adults, only one was a second nesting attempt following a successful nesting attempt earlier in the season. Banded chickadees were observed attempting to renest only once following an unsuccessful nesting attempt earlier in that year. Adults that made nesting attempts in more than one year were paired after their initial year with their previous mates in 20 of 41 (48.8%) cases. Chickadees made subsequent nesting attempts either in (22 of 49 cases; 44.9%) or near (27 of 49 cases; 55.1%) the nest cavity that was initially used.

Bird blow fly (*Protocalliphora deceptor*) larvae and/or pupae were present in 85 (71.4%) of the 119 chickadee nests that I inspected; the mean number of immature flies per parasitized nest was 26.8 (range 1-94). The number of immature blow flies present was not significantly correlated with the dates on which chickadee eggs were laid or with chickadee clutch size. Nests that were parasitized and nests that were not parasitized did not significantly differ in mean clutch size or in the mean number of nestlings fledged, but immature blow flies occurred more often in nests where a significantly larger number of chickadee eggs hatched.

INTRODUCTION

Several published reports have documented various aspects of the biology of Carolina Chickadees (*Poecile carolinensis*). In a classic study, Tanner (1952) compared the altitudinal distribution of Carolina Chickadees and Black-capped Chickadees (*P. atricapillus*) in the southern Appalachian Mountains. In other studies of Carolina Chickadees, Dixon (1963) reported on social organization, Smith (1972) described communication and social behavior, Pitts (1976a) documented winter roosting habits, and Wood and Lustick (1989) examined physiological responses to cold temperatures.

Reports of Carolina Chickadee nesting biology were published by Brewer (1961, 1963) who summarized (from the literature, correspondence with other biologists, and his personal observations) information on 63 clutches. Mowbray and Goertz (1972) tabulated their observations on 110 Carolina Chickadee nesting attempts in north Louisiana but provided few details. Albano (1992) studied nesting mortality in 56 nesting attempts in natural cavities in Illinois. The *Tennessee Breeding Bird Atlas* (Pitts 1997) included information about 55 Carolina Chickadee nests in natural cavities. Other than some anecdotal reports (e.g., Odum 1942, Conner 1974, Potter 1976, Pitts 1978), little additional information on the breeding biology of Carolina Chickadees is available, and many aspects of their reproductive biology

have not been described. In this paper I present data on 214 Carolina Chickadee nesting attempts that I observed in artificial nest structures during 25 nesting seasons in Tennessee.

STUDY AREA AND METHODS

Artificial nesting cavities. The Carolina Chickadee nests described in this study were constructed either in wooden nest boxes, wooden nest posts, or polyvinyl chloride (PVC) nest tubes. The boxes had been erected for Eastern Bluebirds (*Sialia sialis*) while the posts and tubes were prepared for Carolina Chickadees. The total number of artificial nest cavities (boxes, posts, and tubes) present on the study areas each year ranged from 27 in 1970 to 86 in 1974 with an average of 56 available each year (Table 1). These artificial nest cavities were available for a total of 1460 nest cavity-years. (One nest cavity-year equals one nest cavity available for one nesting season.) During the 26-year period of this study, all of the posts and many of the boxes decayed; vandals, livestock, or farming operations destroyed other boxes. The entrance to each cavity was 1.4 to 2.0 m above the ground and typically faced some direction other than west, the direction of the prevailing winds. Nest boxes were placed a minimum of 90 m apart along fence rows, at the margins of roads, and at the intersection of pasture (or other open land) and woodland; all of the boxes were either in or adjacent to grasslands. The posts and PVC tubes were placed at least 45 m apart either in, or at the edges of, wooded areas.

Nest boxes were constructed of 1.9-cm thick wood, had 3.8-cm diameter entrance holes, were either unpainted or were painted a light color such as pale green or gray, and had various floor sizes (70 to 150 cm^2). Prior to 1975 all of the nest boxes were attached to wooden fence posts; during the 1975-1995 nesting seasons each of the boxes was supported by a 2.5 to 5-cm diameter electrical conduit metal post. Nest boxes were the most abundant type of artificial nest cavity on my study sites. The number of nest boxes present each year varied from a low of 27 in 1970 to a high of 86 in 1974. Nest boxes were available for 1240 nest cavity-years.

I constructed nine nest posts specifically for Carolina Chickadees. These structures were prepared by chiseling out a cavity approximately 7 cm in diameter and 18 cm deep in dry sassafras (*Sassafras albidum*) posts that were 2 m long and approximately 12 cm in diameter. Each cavity had an entrance, 3.2 cm in diameter, on the side. I examined the contents of the cavity and removed debris through a hinged back. The nest posts were not painted. They were set into postholes approximately 0.5 m deep. One of the nest posts remained in a useable condition as a chickadee nest cavity for nine years; none of the other posts was suitable for use as a nest cavity after six years due to decay of the post or destruction of the cavity by woodpeckers or squirrels. Nest posts were available for 52 nest cavity-years.

Table 1. Number of artificial nest cavities available, number of Carolina Chickadee nesting attempts, and nesting results for 1970-1972 and 1974-1995.

Year	Number of Cavities Available	Number of Chickadee Nests[a]	Number of Successful Nests[b]	Percent of Nests that were Successful	Total Number of Eggs Laid	Total Number of Eggs Hatched	Total Number of Young Fledged	Percent of Eggs Laid to Produce Fledglings	Percent of Eggs Hatched to Produce Fledglings
1970	27	0	-	-	-	-	-	-	-
1971	32	1	0	0.0	3	2	0	0.0	0.0
1972	38	1	1	100.0	5	3	3	60.0	100.0
1974	86	7	2	28.6	29	10	10	34.5	100.0
1975	52	2	2	100.0	9	7	5	55.6	71.4
1976	63	5	4	80.0	26	22	22	84.6	100.0
1977	60	4	1	25.0	24	22	5	20.8	22.7
1978	70	8	8	100.0	55	44	39	70.9	88.6
1979	69	17	15	88.2	103	81	79	76.7	97.5
1980	64	15	13	86.7	86	79	74	86.0	93.7
1981	69	14	12	85.7	82	68	67	81.7	98.5
1982	60	17	12	70.6	94	61	49	52.1	80.3

1983	63	19	6	31.6	89	45	12	13.5	26.7
1984	70	9	2	22.2	46	24	4	8.7	16.7
1985	71	5	3	60.0	25	8	8	32.0	100.0
1986	53	3	2	22.2	14	12	8	57.1	66.7
1987	61	8	7	60.0	45	37	37	82.2	100.0
1988	44	3	2	66.7	18	8	8	44.4	100.0
1989	51	8	6	75.0	44	39	33	75.0	84.6
1990	43	3	2	66.7	12	10	8	66.7	80.0
1991	46	7	6	85.7	39	33	31	79.5	93.9
1992	67	9	7	77.8	48	39	33	68.8	84.6
1993	68	19	14	73.7	99	85	67	67.7	78.8
1994	37	13	13	100.0	70	64	63	90.0	98.4
1995	40	17	10[c]	58.8	99	89	43	43.4	48.3
	MEAN = 56.2	SUM = 214	SUM = 150	MEAN = 70.1	SUM = 1164	SUM = 892	SUM = 708	MEAN = 60.8	MEAN = 79.4

[a]Nests in which at least one egg was laid.
[b]Nests from which at least one young fledged.
[c]Based on 14 nests; the fates of three nests were not determined.

The third type of nest cavity that I provided was constructed of white 5-mm thick PVC. Each tube was 30 cm tall, either 7.6 cm or 10.2 cm in internal diameter, and had a 3.2-cm diameter entrance on the side. The bottom of the entrance was approximately 16 cm above the floor of the tube. The floor was a 1.9-cm thick piece of wood. A removable top was constructed of a 13-cm by 13-cm fiberglass plate attached to a wooden cylinder 4-cm thick that slid into the PVC tube. The PVC tubes were painted either brown, gray, or green on the outside but remained white on the inside. PVC tubes, which were in place during 1989-1995, were attached to 4-cm diameter metal posts. I partially filled some of the 7.6-cm diameter PVC tubes with sawdust and small wood chips prior to each nesting season. The 7.6-cm diameter PVC tubes were available for 147 nest cavity-years. The 10.2-cm diameter PVC tubes were available for 21 nest cavity-years.

To determine if birds had a preference for nest cavity size, I placed ten pairs of nest boxes on the Obion County study site (described below) in 1977. Each pair consisted of a Small Box with a floor area of 71.5 cm^2 and a Large Box with a floor area of 143 cm^2; the boxes were identical except for size. The paired boxes were located about 75 cm apart on two horizontal strips of wood supported by a metal post. For additional information about these paired tests see Pitts (1988). At another site, chickadees had a choice of a Very Small Box with a floor area of 36 cm^2 or a Small Box (floor area = 71.5 cm^2).

Study sites. The study sites were beef cattle pasture lands interspersed with woodlots consisting of hardwoods such as oak (*Quercus* spp.) and hickory (*Carya* spp.). One study site was in Obion County and the other was in Weakley County; these counties are adjacent to each other in northwest Tennessee. The two study sites were approximately 50 km apart. The Weakley County site consisted of 16-160 ha (the size varied by year). On the Obion County site most nest boxes were placed either adjacent to, or within 100-m of, secondary roads rather than concentrated on particular farms as in Weakley County. The length of the Obion County site varied from 5 to 11 km. Many fields in the Obion County study site were converted from pastures into row crops during my study. Additional information about the study sites is available in Pitts (1976b, 1988). My investigations were limited to Obion County in 1970-1975; most of my 1976-1982 data are from Obion County with a few observations from Weakley County. Virtually all of my 1983-1995 data are from Weakley County.

Data collection and analysis. Some of the nest boxes on the Obion County site were erected in the late 1950's; prior to 1970 and in 1973 I did not inspect the boxes frequently enough to adequately document nesting activities of their occupants. I inspected each of the nest cavities and made notes about the contents at least once per week during the nesting seasons of 1970-1972 and 1974-1995; some of the cavities with an active nest were inspected

daily. At three nests I used dial calipers to measure the maximum length and maximum width of the eggs.

After each chickadee nesting attempt I removed all nest material and debris from the nest cavity. If the nest had not been damaged by predators or decay, I disassembled it and counted the number of blow fly larvae and pupae that were present. In 1979, I collected and stored (in a plastic bag at room temperature) the blow fly pupae from a chickadee nest in Weakley County. After the adult blow flies emerged from their pupa cases, I shipped four of them to C. W. Sabrosky at the National Museum of Natural History for identification.

I banded many (n = 509), but not all, of the nestling chickadees that were reared in the artificial nest cavities. I captured and banded adult chickadees (n = 288) either by trapping them in the nest cavity as they fed nestlings or by using modified McCamey (1961) traps stocked with sunflower seeds during December-February. My winter banding efforts were not systematic with respect to either time or location but took place primarily on two farms, one in Obion County and one in Weakley County. Each captured adult received a unique combination of colored plastic leg bands in addition to the numbered U. S. Fish and Wildlife Service aluminum band. I estimate that less than 20% of the adult chickadees that used my artificial nest structures had access to feeders during the winter prior to their nesting attempts. I attempted to identify the adults at some, but not all, nests by observing their colored leg bands with a 20X spotting scope.

Statistical analyses were performed with JMP Version 3.1 (SAS Institute 1995). P values of 0.05 or less were considered to be statistically significant. The name of each test is given following its use.

I determined the date on which the first egg in each clutch was laid either (1) by checking the nest daily or (2) by counting the number of eggs present and back-dating, with the assumption that one egg was laid each day. For some of the small clutches that were laid in cavities that I inspected only once per week, I back-dated and then subjectively estimated the dates of laying. My estimates were influenced by the date (because nests were constructed much more rapidly later in the nesting season) and by the contents of the nest cavity on my last inspection prior to the date when I observed eggs. For example, if a cavity that was empty at mid-day on 10 May contained a complete clutch of 3 eggs on 17 May, I assumed (allowing 2 days for nest construction) that the first egg was laid on either 13 May, 14 May, or 15 May. I would have selected the middle date, 14 May, as the representative date for the laying of the first egg. If the cavity had contained a completed nest at mid-day on 10 May, the first egg could have been laid on any of the days 11 May-15 May and I would have selected 13 May as the representative date for the laying of the first egg.

Definitions. I use the term "artificial cavity" to refer to the nest boxes, nest posts, and nest tubes that I constructed and placed on the study sites. In

contrast, "natural cavities" are produced by events, such as the excavation of nest and roost cavities by woodpeckers or the decay of tree limbs and trunks, that occur independently of human activity.

The term "nesting attempt" refers to the construction of a nest and the laying of at least one egg in that nest by the nest builder. The construction of a nest, regardless of the amount of time used or energy expended, was not considered to be a "nesting attempt" until I detected the presence of an egg. A chickadee egg deposited on the bare floor of a nest cavity or in the nest of another species was not considered to be a "nesting attempt."

I applied the term "successful nest" to any nest from which, based on supporting evidence, at least one nestling fledged. In a few cases I observed young chickadees fledge. At most nests I estimated the number of fledglings on the basis of the available evidence. For example, if a nest had six apparently healthy nestlings that were near fledging age on Monday, and I next visited the nest on Friday and found that it was empty except for one dead nestling, I assumed (unless I found evidence of disturbance or depredation) that the other five young had fledged.

The term "parid" refers to a group of birds that includes the various species of chickadees and titmice of North America and the tits of Europe, Great Britain, and other parts of the world. Formerly these species were all included in the genus *Parus*; recently, however, the genus was split and the Carolina Chickadee was placed in the genus *Poecile* (American Ornithologists' Union 1997).

RESULTS

Use of artificial nest cavities. I observed a total of 214 Carolina Chickadee nesting attempts; eight of these were in posts, 63 were in PVC tubes, and 143 were in boxes. The number of nesting attempts each year in the artificial cavities ranged from none in 1970 to 19 in 1983 and in 1993 (Table 1) with an average of 8.6 per year. Ninety-two nesting attempts were on the Obion County study area and 122 were on the Weakley County study area.

On several occasions chickadees carried nesting material into an artificial cavity but then abandoned the site before laying any eggs. Many of these nests were obviously incomplete but others appeared to be complete. These abandoned nests are not considered further in this paper. Some, perhaps several, chickadees may have nested in natural cavities on the study areas, but I have no data from those nests. In four cases, a banded female skipped a year or more between nesting attempts in the artificial cavities; I suspect these females nested in natural cavities during those years when they did not use the artificial cavities.

At the ten sites where Large-Small boxes were paired, chickadees built 21 nests, and at the one site with a Small-Very Small pair of boxes, chickadees built four nests. Chickadees built each of these 25 nests in the smaller of the two boxes at the site ($X^2 = 25$, df = 1, $P < 0.001$).

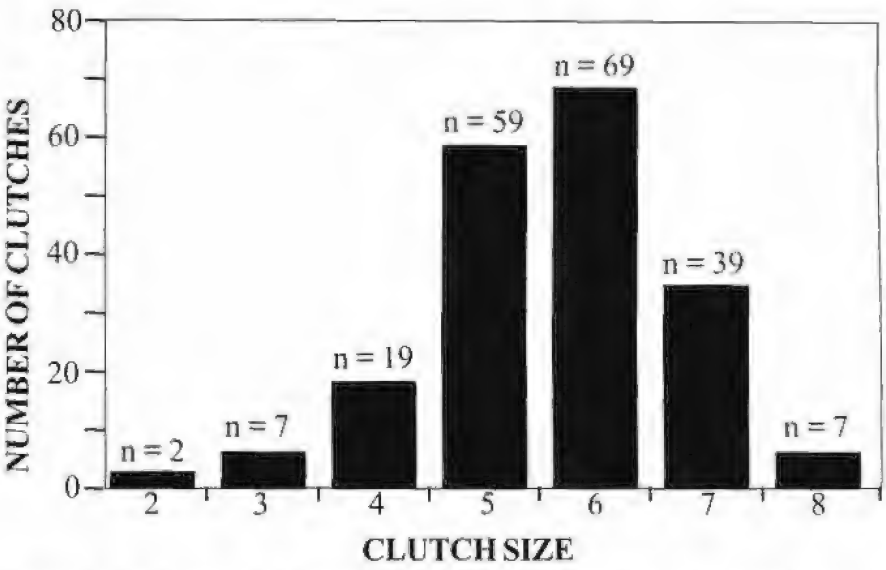


Figure 1. Frequency of different sizes of 202 Carolina Chickadee clutches.

Eggs and egg-laying. Clutch size ranged from 2-8 with a mean of 5.64 (SE = 0.08) for the 202 nests where the clutch was completed; 12 other nests were either destroyed by predators or were abandoned by the chickadees before the clutch was completed. The modal clutch size was 6 (n = 69, 34.2% of the completed clutches); the next most common clutch size was 5 (n = 59, 29.2% of the completed clutches) (Figure 1).

The first egg in the earliest clutch was laid on 11 March and the first egg in the latest clutch was laid on 28 May, a span of 79 days. Approximately 82% of the clutches were initiated during the thirty-day period of 21 March-19 April (Figure 2). The mean date of laying first eggs in all clutches was 6 April; the five-day period with the largest number of clutch initiations was 26-30 March (Figure 2). Clutch size declined as the nesting season progressed (Figure 3). This decline was statistically significant (ANOVA: $F_{1, 200} = 54.26$, $r^2 = 0.21$, $P < 0.0001$). The equation for predicting clutch size on a specific date is:

CLUTCH SIZE = 9.43 – 0.04 (JULIAN DATE OF FIRST EGG IN CLUTCH)

No clutches of 8 were initiated after 7 April; all of the clutches of 6 and 7 were initiated before the end of April. While some of the smaller clutches (2-5 eggs) were initiated in March, the first eggs were not laid in most of the clutches of these sizes until much later.

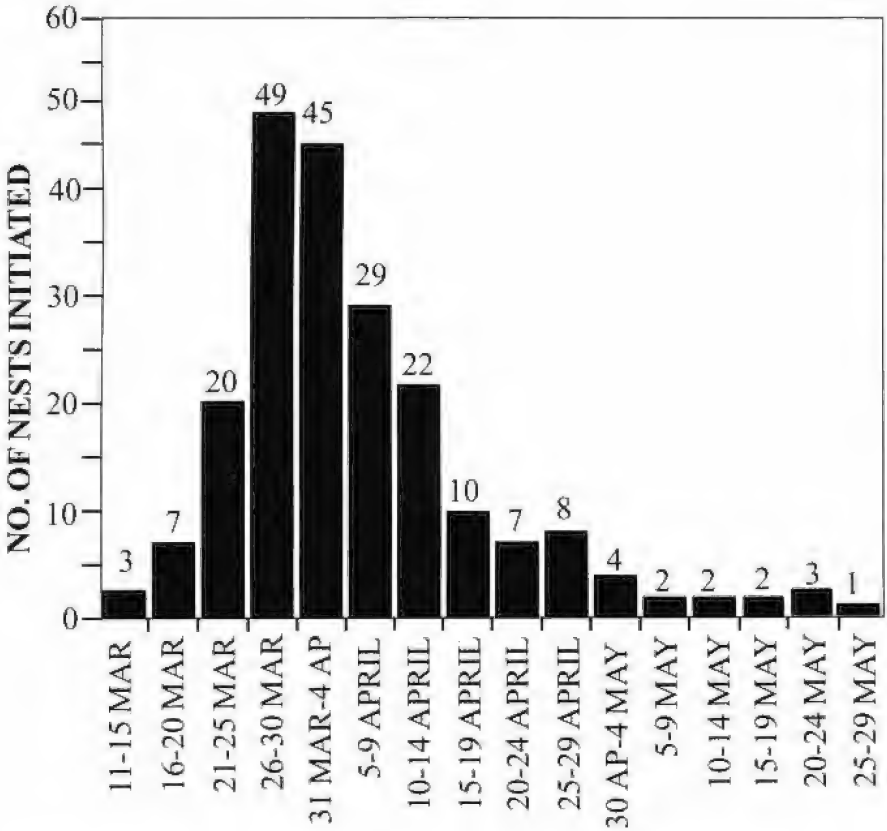


Figure 2. Number of Carolina Chickadee nests initiated per five-day period.

Clutch size in 7.6-cm PVC tubes (mean = 5.56, SE = 0.15, n = 59), in 10.2-cm PVC tubes (mean = 6.00, SE = 0.67, n = 3), in posts (mean = 5.29, SE = 0.44, n = 7), and in boxes (mean = 5.69, SE = 0.10, n = 133) did not significantly differ (ANOVA: $F_{3,198} = 0.54$, P = 0.66). Clutch size in Obion County (mean = 5.74, SE = 0.13, n = 86) was similar to the clutch size in Weakley County (mean = 5.56, SE = 0.11, n = 116); this difference is not significant (t = 1.11, df = 200, P > 0.27). Because of the lack of significant differences between clutch sizes in the four types of cavities and between clutch sizes on the two study sites, data from all types of nest cavities and from both study sites were merged. Linear regression of clutch size on box size (= floor area) showed a positive relationship between clutch size and box size (CLUTCH = 5.36 + 0.004 (BOX SIZE)); however, this relationship was not statistically significant (ANOVA: $F_{1,130} = 1.16$, $r^2 = 0.009$, P = 0.28).

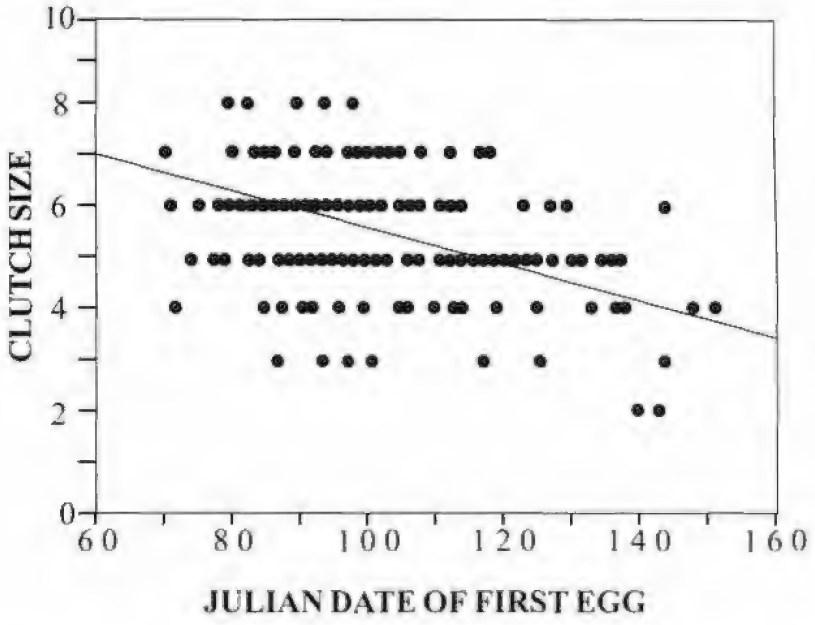


Figure 3. Relationship between Carolina Chickadee clutch size and date of laying for 202 Carolina Chickadee clutches.

All of the clutches of 8 were laid on the Obion County study site in the years 1978-1983; two of these clutches were laid by the same female. Thirteen (61.9%) of the 21 females that nested more than one year, including one that nested three years and one that nested five years, laid the same size clutch each year.

Female chickadees normally laid eggs at the rate of one per day on consecutive days until the clutch was completed. At two nests the females apparently skipped one or more days in the laying sequence. At nest 191 the female skipped a day between the laying of egg 2 and egg 3 of a 6-egg clutch. She laid egg 1 on 29 March and egg 2 on 30 March; she did not lay on 31 March but then laid eggs 3-6 on 1-4 April. At nest 106 the female skipped 3 days between the laying of egg 2 and egg 3; she also skipped either one or two days between the laying of egg 3 and egg 4. In this clutch of five the first egg was laid on 26 March, the second on 27 March, the third on 31 March, the fourth on either 2 or 3 April, and the fifth on 4 April.

Female chickadees sometimes laid an egg at a site other than their nest cavity. On two occasions at sites where chickadees had a choice of two adjacent nest cavities, the female laid an egg in one of the cavities and all of the remaining eggs of her clutch in the other cavity. On the Obion County study site I found one chickadee egg in an active House Sparrow nest. On

other occasions I found chickadee eggs that had been laid in a nest cavity that contained little nest material. In some cases the eggs were laid directly on the floor of the cavity among a few pieces of green moss. In one large nest cavity (a wooden box) the female chickadee deposited green moss and then formed and lined two nest cups; all of the eggs were laid in one nest cup.

The 18 eggs in the three clutches that I measured had a mean length of 15.60 mm (range = 14.75-16.29 mm, SE = 0.10) and a mean width of 12.05 mm (range = 11.46-12.57 mm, SE = 0.07). Each of these clutches was laid by a different female. One of the clutches contained four eggs and each of the other two contained seven eggs. The mean length and mean width of the eggs in the clutch of four (16.06 mm x 12.39 mm) were greater than the means for the clutches of seven (15.79 mm x 12.15 mm and 15.15 mm x 11.75 mm, respectively). The mean lengths and mean widths of the clutch of four and the first seven-egg clutch did not significantly differ. The mean length and mean width of the eggs in the second 7-egg clutch were significantly smaller than the means of the eggs in the other clutches ($P < 0.05$, Tukey-Kramer HSD).

Banded nestlings and adults. I banded 509 of the 892 nestlings that were present in artificial nest cavities on the study sites. Excluding the 42 nestlings banded during the last year of the study (1995), 467 of these banded birds could potentially have nested during the study. I identified six (1.3%) of them as nesting adults. Three were females and three were males. These six individuals constituted 5.4% of the 112 chickadees that I identified as nesting adults during the study.

I identified either one or both of the adults in 100 nesting attempts. At 70 of these nesting attempts both adults were identified; at 24 nesting attempts only the female was identified, and at six nesting attempts only the male was identified. Forty-eight males were identified; 33 (68.8%) were seen during only one year, ten (20.8%) were present for two years, three (6.3%) were present for three years, and two were present for four years. Sixty-four females were identified; 43 (67.2%) of them were seen during only one year. Seventeen (26.6%) females were identified in two nesting seasons, three (4.7%) were seen in three nesting seasons, and one nested on the Weakley County area for five consecutive years. The oldest chickadee that I encountered survived ten winters on the Weakley County study site, but this bird never nested in any of the nesting structures that I provided.

In 41 cases the adult chickadee that I identified at a nesting attempt had been identified at a nesting attempt in previous years. The identified individual was with its previous mate in 20 (48.8%) cases but changed mates in 21 (51.2%) cases. At the 22 nesting attempts involving previously nesting males, the same female was present at ten (45.5%) but a different female was present at 12 (54.5%). At the 19 nesting attempts with previously nesting females, the same male was present at ten (52.6%) and a different male was present at nine (47.4%).

Of 49 cases where an adult was known to have made a nesting attempt in a previous year, the chickadee remained at the same nest site 22 (44.9%) times but moved to a nearby nest cavity 27 (55.1%) times. Males reused their previous nest site 9 of 22 (40.1%) times and changed sites 13 of 22 (59.1%) times. Females reused their previous nest site 13 of 27 (48.1%) times and moved to a different site 14 of 27 (51.9%) times. Most of the nest site changes that I documented, for both males and females, were to a nearby nest structure and involved movements of less than 100 m from the initial nest cavity.

Individual chickadees varied in their fidelity to mates and nest sites. For example, male # 743 and female # 760 remained paired with each other through four nesting seasons during which they used two nest sites. In contrast, male # 757 had three successive mates and used two nesting sites in the three nesting seasons he was identified, and male # 761 had a different mate and used a different nesting site in each of the four nesting seasons he was present. Some individuals remained at a nest site throughout their documented life; for example, male # 758 used the same site for three consecutive years and had a different mate each year. Other individuals, such as male # 605, changed nest sites but remained with their original mate.

Of the 100 nesting attempts where I identified banded adults, 80 were successful and 20 failed to produce any fledglings. From these 100 nesting attempts, I documented two cases in which banded chickadees made more than one nesting attempt in a single season. (1) One of the 80 successful nesting attempts was followed by another nesting attempt that year by the same pair. In 1979, female # 179 and male # 174 had two successful nests. The clutches were initiated on 25 March and 13 May; the second nest was in a different cavity, approximately 70 m from the first site. In their first nest, all 7 eggs hatched and 5 young fledged; in their second nest all 5 eggs produced fledglings. (2) Following the 20 nesting attempts that failed, I observed one case of renesting. In 1980, female # 709 abandoned her nest with 2 eggs (probably an incomplete clutch) after Eastern Bluebirds remodeled the nest; she successfully renested about 200 m away. She laid the first egg in the first clutch on 11 April. Her second clutch, which contained 3 eggs, was initiated on 17 May, one of the latest clutches I observed. Only four (of 214) clutches were initiated later than this. I identified her mate at the replacement nest but not at the first nest.

Chickadees initiated egg-laying in 12 nests on or after 1 May; both of the second nesting attempts described above were in this group. I did not identify the adults at the other 10 nests initiated in May.

Nest success. One hundred fifty (70.1%) of the 214 nesting attempts were successful (i.e., produced at least one fledgling) (Table 1). Of 1164 eggs laid, 892 (76.6%) hatched and 708 nestlings fledged; 60.8% of the eggs laid and 79.4% of the eggs that hatched produced fledglings (Table 1). Sixty-four nests (29.9% of the 214 nesting attempts) were total failures (i.e., failed

Table 2. Causes of failure at 64 Carolina Chickadee nests where no young fledged.

I. Nest abandoned with eggs and/or young present; no evidence of predation or competition from other cavity nesting species of bird.

CAUSE	NO. NESTS
Unknown	18
Cold or rainy weather	11
Cowbird parasitism	2
Human interference	2
Disturbance by livestock	1
TOTAL	34

II. Nest contents (eggs and/or young) taken or destroyed by predator.

PREDATOR	NO. NESTS
Unidentified	7
Flying Squirrel	4
Snake	3
Raccoon	1
TOTAL	15

III. Nest cavity commandered by another species of bird.

SPECIES	NO. NESTS
Eastern Bluebird	6
House Sparrow	6
Prothonotary Warbler	1
Tufted Titmouse	1
TOTAL	14

IV. Adult chickadee died in nest; no evidence of predation or competition from other secondary cavity nesting species of bird.

SEX	NO. FOUND DEAD
Female	1
Male	0
TOTAL	1

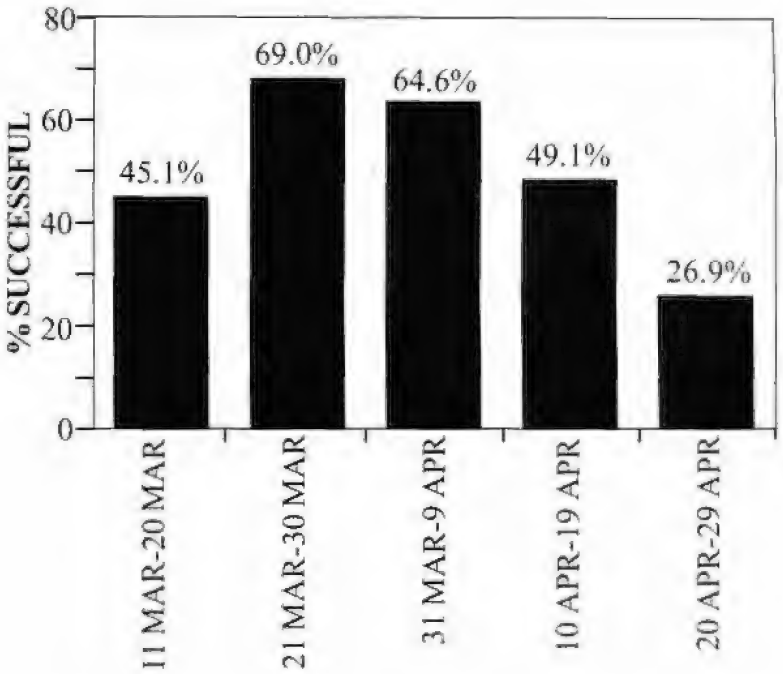


Figure 4. Nest success (number of young fledged/number of eggs laid) per 10-day interval in which 50 or more eggs were laid.

to produce any fledglings); 182 eggs and 127 young were lost in these nests. Causes of the failures are summarized in Table 2. Thirty-seven (57.8%) of the failures occurred during the egg stage (12 during egg-laying and 25 during incubation); 16 (25.0%) failed while young were present in the nest, and 11 (17.2%) nests that were total failures lost both eggs and young. Eggs laid between 21 March-9 April were more likely to produce fledglings than were eggs laid either earlier or later in the year (Figure 4).

In the 150 successful nests, the number of fledglings ranged from 1-8 with an average of 4.7 (SE = 0.13) per nest. All of the eggs hatched and produced fledglings at 71 nests (33.2% of the total nests; 47.3% of the successful nests). At the partially successful nests (where some, but not all, of the eggs produced fledglings; n = 79; 36.9% of the total nests; 52.7% of the successful nests), 47 nests lost only eggs, 18 nests lost only young, and 14 nests lost both eggs and young but still produced some fledglings. Eighty-nine eggs and 57 young were lost in these nests. The fates of the nests are summarized in Table 3. The mean number of young fledged per successful nest in 7.6-cm PVC tubes (mean = 4.74, SE = 0.24, n = 46), in 10.2-cm PVC

Table 3. Summary of production and losses at 214 Carolina Chickadee nests.

I. Nests that were totally successful (all eggs hatched and produced fledglings):

	No. Nests	Losses Eggs	Losses Young	Young Fledged
Subtotals	71	0	0	401

II. Nests that were partially successful (some, but not all, of the eggs produced fledglings):

	No. Nests	Losses Eggs	Losses Young	Young Fledged
Only eggs lost	47	69	0	204
Only nestlings lost	18	0	33	67
Both eggs and nestlings lost	14	20	24	36
Subtotals	79	89	57	307

III. Nests that were a total failure (no young fledged):

	No. Nests	Losses Eggs	Losses Young	Young Fledged
Only Eggs lost	37	162	0	0
Only nestlings lost	16	0	88	0
Both eggs and nestlings lost	11	20	39	0
Subtotals	64	182	12	0
Totals	214	271	184	708

tubes (mean = 6.00, SE = 1.14, n = 2), in posts (mean = 4.33, SE = 0.66, n = 6), and in boxes (mean = 4.71, SE = 0.17, n = 96) did not significantly differ (ANOVA: $F_{3, 146} = 0.54$, $r^2 = 0.01$, $P = 0.66$).

Nesting success varied greatly between years. Nesting success was low in 1983 and 1984 (Table 1) when, for the two years combined, only 8 of 28 nests (28.6%) were successful and 16 young (11.9%) fledged from the 135 eggs laid. In contrast, nesting success was highest in 1994 when 13 of 13 nests (100%) were successful and 63 of the 70 eggs laid (90.0%) produced young. Because of the small number of nesting attempts in the artificial nest cavities in several years, I did not attempt a statistical analysis of factors (such as temperature and precipitation) that might cause variations in nest success between years.

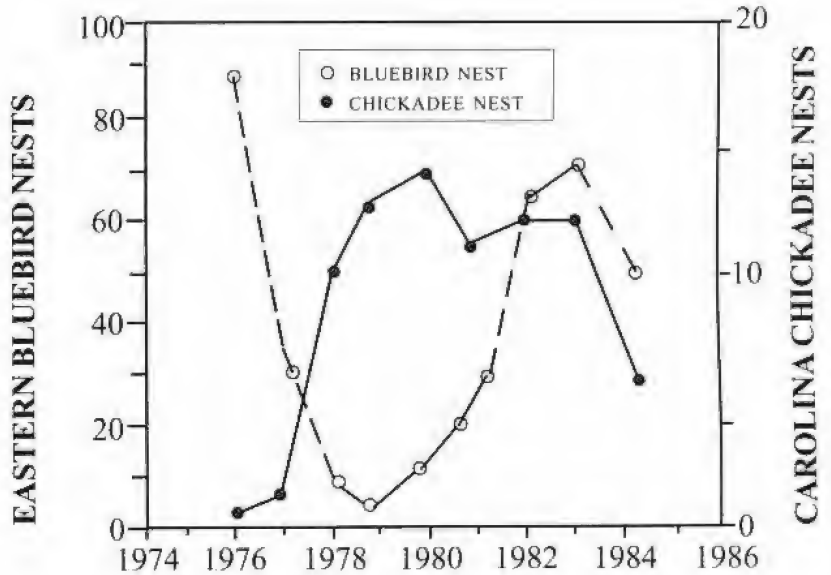


Figure 5. Comparison of numbers of Eastern Bluebird nesting attempts and Carolina Chickadee nesting attempts during a population crash of Eastern Bluebirds on the Obion County, Tennessee study site.

Use of artificial cavities by other species of birds. Brown-headed Cowbirds (*Molothrus ater*) laid an egg in each of two chickadee nests; both of these nesting attempts subsequently failed. The failure of these nesting attempts might not have been due to the cowbirds since nearby farming operations could have disrupted the chickadees. At both nests, the entry hole of the nest box had been enlarged during the previous winter by either woodpeckers or squirrels. I also observed that Eastern Bluebird nests on the study areas were parasitized by cowbirds only when the nest box entry had been enlarged (Pitts, personal observation).

During the 25 years of this study, Eastern Bluebirds made 1355 nesting attempts in the nest cavities that I monitored. Bluebirds usurped six chickadee nests with eggs (Table 2) and nine chickadee nests that were in various stages of construction prior to egg-laying. (These nine nests were not counted as nesting attempts, and they could not be included in Table 2 as losses since I did not detect eggs in the nest.) In each of these 15 cases, bluebirds took ownership of the cavity away from chickadees, constructed their own nest on top of the chickadee nest, and laid eggs. At other cavities, bluebirds interrupted nest construction by chickadees, but subsequently the bluebirds departed and the chickadees resumed nest construction. This sequence of events resulted in a

nest with green moss on the bottom (deposited by chickadees), a middle layer of grass (deposited by bluebirds), and then a top layer of green moss with the fur lining of the chickadee nest. In other cases chickadees constructed their nest in a partially constructed nest that bluebirds had abandoned.

When the bluebird population on the Obion County study area declined in the late 1970's (Pitts 1981), the number of chickadee nests in bluebird nest boxes increased (Figure 5). Prior to the bluebird population crash, chickadees rarely nested in bluebird nest boxes; shortly after the recovery of the bluebird population, the number of chickadee nests in bluebird nest boxes declined (Figure 5).

Other secondary cavity nesting birds that competed with chickadees for nest cavities on the study sites included Tufted Titmice (*Baeolophus bicolor*), Carolina Wrens (*Thryothorus ludovicianus*), House Sparrows (*Passer domesticus*), and Prothonotary Warblers (*Prothonataria citrea*). The first three were abundant on both the Obion County and Weakley County study sites, whereas Prothonotary Warblers commonly nested on the Weakley County study site, but not on the Obion County study site. The total number of nesting attempts by each of these species was: House Sparrow--216; Tufted Titmouse--25; Prothonotary Warbler--18; and, Carolina Wren--14. At nest boxes where the entrance had been enlarged by woodpeckers, European Starlings (*Sturnus vulgaris*) made five nesting attempts, and Great Crested Flycatchers (*Myiarchus crinitus*) had one nesting attempt. In addition, southern flying squirrels (*Glaucomys volans*) built 33 nests, 15 of which received litters (Pitts 1992). Paper wasps (*Polistes* sp.) built nests in most of the nest cavities that were not used by birds or squirrels.

I found five dead adult chickadees that, based on circumstantial evidence, I concluded were killed by competing species of secondary cavity nesting birds that either had previously or subsequently nested in or near the cavity where I found the dead chickadee. I suspected that House Sparrows killed two of these chickadees, Tufted Titmice killed two, and a Prothonotary Warbler killed one. Four of the chickadees were found in nest cavities and one was found on the ground beneath a nest cavity. One chickadee was known to be a female, two were thought to be females, and the sex of the other two was not known. Each of the chickadees had massive injuries, primarily in the head region. In three cases the nest cavity contained an active chickadee nest with eggs; in one case the nest cavity was empty, and in the other case the nest cavity contained a Tufted Titmouse nest with eggs. In the last case, the dead chickadee had nested in that cavity the previous year.

Blowflies. Of the 119 chickadee nests that I inspected for bird blow flies, 34 (28.6%) did not contain any evidence of blow fly parasitism. In the other 85 (71.4%) nests I found larvae and/or pupae of bird blow flies. In six nests with blow flies I could not accurately count the flies; in the remaining 79 nests the number of immature blowflies per nest ranged from one to 94 with

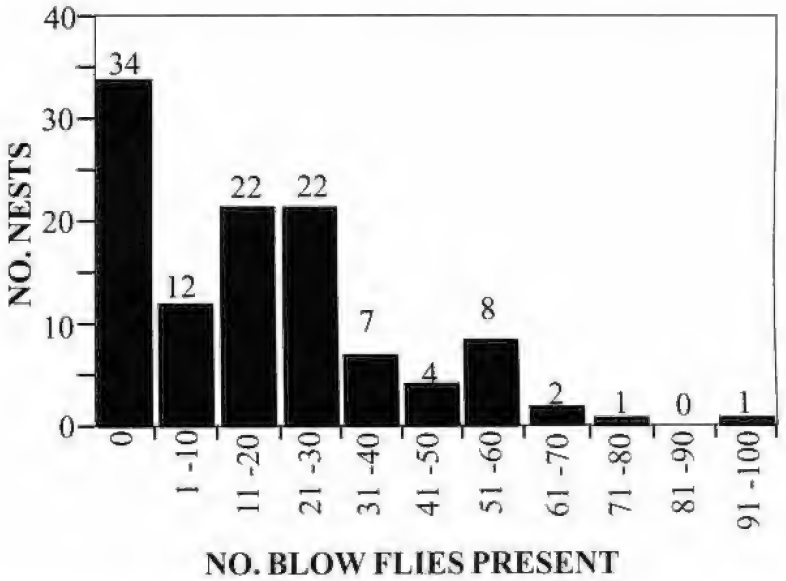


Figure 6. Number of immature bird blow flies present in 113 Carolina Chickadee nests.

a mean of 26.8 (SE = 2.05, n = 79) (Figure 6). The mean date for the laying of the first chickadee egg in nests that were parasitized (Julian date 93.1) was not significantly different (t = – 1.62; P = 0.11) from the date for the laying of the first chickadee egg in nests that were not parasitized (Julian date 97.1). The number of immature blow flies present was not significantly correlated with the date on which chickadee eggs were laid (r^2 = 0.014, ANOVA $F_{1, 78}$ = 1.12, P = 0.29) or chickadee clutch size (r^2 = 0.001, ANOVA $F_{1, 78}$ = 0.10, P = 0.75).

A comparison of chickadee nests with blow flies and chickadee nests without blow flies showed no significant differences in mean clutch sizes (5.5 in nests with blow flies vs. 5.7 in nests without blow flies; t = 0.71; P = 0.48). There were also no significant differences in the mean number of young fledged per nest (4.3 from nests with blow flies vs. 3.9 from nests without blow flies; t = 0.98; P = 0.33). However, blow flies were more likely to occur in nests where larger numbers of chickadee eggs hatched. There was a significant difference (t = 2.69; P = 0.008) in the number of eggs that hatched in nests that subsequently had blow flies (mean = 5.2) and in nests without blow flies (mean = 4.4).

Chickadee nests built in the later years of the study were more likely to be parasitized than were nests built in earlier years (mean year for nests with

blow flies = 1989.3; mean year for nests without blow flies = 1985.8; t = 3.04; P = 0.003). The percentage of the chickadee nests that was parasitized was higher in Weakley Co. (75.0%) than in Obion Co. (62.9%), but the number of immature blow flies per parasitized nest did not differ between the two sites (Obion Co. mean = 25.8; Weakley Co. mean = 27.0; t = – 0.26, P = 0.80). In 1989, Sabrosky et al. (1989) named the new bird blow fly species *Protocalliphora deceptor*; they included as paratypes four specimens (two females and two males) that hatched from pupae I had collected.

Length of nesting cycle. I observed chickadees inspecting potential nest and roost cavities throughout the year. As day length increased in January, territorial activity (such as singing by males and chases of same sex individuals by both males and females) occurred more frequently, and individual pairs of chickadees traveled together apart from other members of the winter flock. The initial stage of nest construction, the deposition of green moss, was preceded by varying amounts of cavity excavation (Pitts, personal observation). The number of days during which nest construction occurred was extremely variable. At some sites, the female spent 10-14 days on nest construction while at other sites, particularly in the later part of the nesting season, female chickadees constructed complete nests in 2-5 days. The initiation of egg-laying in relation to nest construction also varied. In some cases the female laid the first egg the day after nest construction was completed but in other cases she did not lay the first egg until 5-7 days after the nest had been completed. Some females continued to add material to the nest lining during the incubation phase of the nest cycle. Egg-laying required 2-8 days, depending on clutch size. As noted above, a female occasionally skipped a day between the laying of eggs. I frequently observed female chickadees roosting in their nest cavities prior to completion of the clutch; I assume that embryonic development was initiated in these eggs. At other nests, I did not see a chickadee on the nest until one or two days after the clutch had been completed.

The incubation period (defined as the number of days from the completion of the clutch until the hatching of the first egg) varied from 11-19 days with a mean of 13.6 days (n = 25). Eggs hatched asynchronously (i.e., over a time span greater than 24 hours) at all 11 of the nests where I determined the time span of hatching. Hatching occurred over a three-day period at one nest and over a two-day period at the other ten nests. I determined the length of the nestling stage at three nests. At one nest all of the young fledged, apparently in response to disturbance, at an age of 16 days. At the other two nests the young remained in the nest for 18 and 19 days, respectively. I observed young fledge from four nests, including the nest where the young remained in the nest 16 days. All of the fledglings flew steadily for distances up to 45 m on their initial flight. I did not attempt to determine the length of time the fledglings were dependent on their parents. Excluding courtship, nest cavity

excavation, and care of fledglings but including nest construction (3-10 days), egg-laying (2-8 days), incubation (11-19 days), hatching (2-3 days) and nestling care (18-19 days), the length of the nesting cycle varied from 36-59 days.

DISCUSSION

Limitations imposed by study methods. The methods that I used to collect data during this study limited the quantity of some types of data that could be collected and imposed biases in other data. In this section I describe some of those consequences that are not mentioned elsewhere in the Discussion.

Although I visited a few of the nest cavities almost daily during some years, I inspected most of the nest cavities only once each week. Consequently, I could not accurately determine the length of events such as incubation and nestling care at most nests, and I may not have completely or accurately documented all of the events, such as the number of eggs that hatched, at some nests.

I did not band any of the chickadee nestlings or adults at some nests. One of the consequences of this is an incomplete documentation of the life span, pair bond duration, and nest site fidelity for several adults. The percentage of the nestlings that I banded and the percentage of the adults that I banded or identified varied between years. This was especially the case during 1970-1991 when my field studies were concentrated on Eastern Bluebirds.

Most of the data for the early years of the study were from Obion County, and all of the data in the later years were from Weakley County. During the middle years of the study, I collected data from both study areas so there was some continuity and overlap of observations as I changed study sites.

The presence of different types of nest cavities biased some of the data I collected. For example, chickadee nests in Eastern Bluebird nest boxes were more likely to be usurped by bluebirds or by House Sparrows than were chickadee nests in nest tubes or nest posts because the 3.8 cm diameter entrance of the nest boxes allowed these larger birds to enter the cavity. Most of the chickadee nests in the last years of the study were in nest tubes with a 3.2-cm diameter entrance which prevented the entry of birds the size of Eastern Bluebirds.

I was able to study ten or more chickadee nests in only eight of the 25 years for which I have data. This small sample size restricted comparisons, such as the effects of weather on nest success, between years. Some of the factors responsible for the low rate of nest box utilization are discussed below.

The biases and limitations described above are partially offset by the length of the study. Information on individual chickadees (such as length of life, mate retention, and fidelity to nest sites) that can only, at best, be inferred

from a short-term study, can be documented in a long-term study of this type.

Paucity of studies of Carolina Chickadee nesting habits. I was surprised to learn that only a few Carolina Chickadee nesting studies have been published. Carolina Chickadees are known to breed in at least 23 states (American Ornithologists' Union 1983) and are commonly observed at feeders, but their nest sites are not easily found or are not readily accessible to humans. Carolina Chickadees, like the Willow Tits (*Parus montanus*) of England, Europe and Asia (Perrins 1979), normally either build their nests in existing natural cavities or in cavities that they have excavated in dead snags and, consequently, neither species consistently uses artificial nest cavities provided by humans. The low rate of nest box utilization has perhaps discouraged investigations specifically aimed at Carolina Chickadees. Consequently, most of the nesting data available on Carolina Chickadees have been acquired as a serendipitous product of other studies (e.g., Mowbray and Goertz 1972, early years of this study). I did not determine how many of the Carolina Chickadees on my study areas nested in natural cavities. Each year I identified chickadees that did not nest in the artificial cavities. I suspect that these birds nested in natural cavities.

Nest cavity selection. Unlike birds such as Eastern Bluebirds which are obligatory secondary cavity nesters and will, consequently, accept many different sizes and shapes of nest cavities, Carolina Chickadees (like many other parids) are capable of excavating their own nest cavity. However, the percentage of chickadees pairs that excavate their nest cavity is unknown. Excavating behavior in chickadees may have functions other than providing a nest cavity. Brewer (1961) suggested that nest cavity excavation, in which both sexes participate, may be part of courtship. If correct, this would help explain why chickadees may not attempt to nest in an empty nest box but instead build their nest nearby in an identical nest box from which they have excavated material. For example, Drury (1958) found that Black-capped Chickadees are more likely to build nests in nest boxes from which they have excavated peat and sawdust rather than in nest boxes that were initially empty. The nest boxes (but not the nest posts and PVC tubes) on my study sites were erected to facilitate my studies of Eastern Bluebirds; none of these boxes contained sawdust or other material that could be excavated, yet chickadees made 143 nesting attempts in them. Brewer (1961) is obviously correct in stating that Carolina Chickadees will use nest cavities, such as nest boxes, in which excavation is impossible; whether or not these pairs had excavated at other sites, and possibly satisfied an instinctive requirement, is not known.

Another factor that may influence Carolina Chickadees as they select a nest site is the external shape of the structure that either is to be excavated or that contains a cavity the chickadees are investigating. The Black-capped

Chickadees studied by Kluyver (1961) built nests in 21 of 60 (35%) circular logs but in only 2 of 17 (12%) rectangular boxes; both types of nest boxes were filled with sawdust and peat. Kluyver (1961) suggested that not only is excavating a part of the normal reproductive pattern, but that Black-capped Chickadees prefer cylindrical nest structures filled with material that can be excavated, similar to naturally occurring snags, rather than empty, rectangular nest boxes. A similar preference by Carolina Chickadees might be responsible, at least in part, for their low rate of nest box utilization. In a one year study that I conducted in east Tennessee, Carolina Chickadees used none of 50 nest boxes that did not contain sawdust and made only three nesting attempts in the 50 nest boxes with sawdust (Pitts 1978). As a result of this low rate of nest box use, I did not continue the study; I suspect that other investigators have experienced similar results.

Another factor that influences Carolina Chickadee utilization of cavities is the diameter of the entrance into the cavity. If the diameter of the entrance is 3.8 cm or greater, cavity nesting species such as Eastern Bluebirds, House Sparrows, and Tufted Titmice can enter the cavity. On my study sites, these larger species frequently either prevented chickadees from using nest boxes (with their 3.8-cm diameter entrances) or usurped nest boxes being used by chickadees. The smaller 3.2-cm diameter entrance to the nest tubes and nest posts allowed chickadees to enter the cavity but blocked the entry of larger species. Whether or not Carolina Chickadees prefer cavities with a smaller diameter entrance is not known. Likewise, I could not determine from the literature the size of the entrance at cavities excavated exclusively by Carolina Chickadees. Brewer (1961) measured the size of the entrance to three cavities used as nest sites by Carolina Chickadees. The entrances averaged 4.02 cm in height and 4.47 cm in width. Brewer (1961) did not indicate whether or not these cavities were excavated by Carolina Chickadees. Albano (1992) found the mean diameter of entrances to 50 natural cavities used as nest sites by Carolina Chickadees to be 4.6 cm with a range from 2.7 to 11.0 cm. Albano (1992) implied that some of these cavities had been excavated by Carolina Chickadees, but he neither stated the number nor presented their measurements separately from those made on previously existing cavities. Downy Woodpeckers (*Picoides pubescens*) typically excavate a cavity entrance that is barely large enough for them to enter and exit (Kilham 1983). I suspect that Carolina Chickadees also excavate small entrances to their nest cavities. The excavation of a small entrance would require less time and the expenditure of less energy than would the excavation of a large entrance. The small entrances to the nests of these small species may also prevent the entry of larger species and facilitate the defense of the cavity against potential predators (Lawrence 1967).

When given a choice of two nest box sizes, the Carolina Chickadees on my study areas clearly preferred the smaller box. This was true whether the

choice was at a site having Small and Large boxes (71.5 cm^2 and 143 cm^2 floor areas, respectively) or at the site with Very Small and Small boxes (36 cm^2 and 71.5 cm^2 floor areas, respectively). At other sites on my study area, chickadees used larger nest boxes, perhaps because no other acceptable cavities or dead snags were available.

Bent (1964) gave the average diameter of Carolina Chickadee nest cavities as 6.0 cm, but he did not indicate how many cavities were measured. Brewer (1961) reported the average diameter of two Carolina Chickadee nest cavities to be 6.5 cm. Albano (1992) measured the internal diameter of 45 natural cavities used as nest sites by Carolina Chickadees; the mean diameter was 7.0 cm with a range of 4.4 to 12.5 cm. Based on these reports, I conclude that Carolina Chickadees most commonly attempt to nest in natural cavities having a diameter of 6-7 cm and a floor area of 28.3 to 38.5 cm^2. This preference may explain why Carolina Chickadees on my study areas consistently selected the smaller nest boxes when given a choice of two sizes.

Perrins (1979) suggested that the use of small nest chambers might (1) reduce the chances of a larger and stronger bird taking over the chamber and (2) make the chamber less accessible to predators. Throughout much of their range, Carolina Chickadees have long had to contend with larger and stronger cavity competitors such as Eastern Bluebirds, Tufted Titmice, and southern flying squirrels. Natural selection has probably favored those Carolina Chickadees that used small nest cavities (that would be inadequate for larger species) and thus reduced the amount of competition with other species. Also, for a primary cavity nester the excavation of a small nest cavity requires a smaller investment of time and energy. A possible disadvantage of small nest cavities is the reduction in clutch size shown by some parids when they nest in small cavities (Perrins 1979). However in my study, nest chamber size did not have a significant effect on clutch size.

Detected and undetected predation. Of the 214 Carolina Chickadee nesting attempts that I studied, only 15 (7.0%) were depredated (Table 2). Albano (1992) found that 21.6% of the 51 Carolina Chickadee nests he studied in natural cavities were depredated, and Christman and Dhondt (1997) concluded that 62% of the 21 Black-capped Chickadee nests they found in natural cavities were depredated. Christman and Dhondt (1997) noted in their review of published studies of nest predation on parids using natural cavities that predation rates varied from 14% to 71%. The 7.0% predation rate that I observed was not within this range.

Carolina Chickadees nesting in the artificial cavities that I provided were better protected, in at least two ways, from predators than were Carolina Chickadees nesting in natural cavities. (1) The smooth metal pipes on which my nest boxes and nest tubes were located were not easily climbed by potential mammalian predators such as raccoons (*Procyon lotor*) and Virginia

opossums (*Didelphis virginiana*) (Pitts, personal observation from Eastern Bluebird study) although southern flying squirrels could enter the nesting cavities (Pitts 1992). Rat snakes (*Elaphe obsoleta*) could climb the metal pipes but rarely did so when the chickadees were nesting (Table 2), probably because rat snakes are not as active in early spring, when chickadees are nesting, as they are later in the year (Stickel et al. 1980). (2) The solid 1.9-cm thick wood walls of the nest boxes and the 5-mm thick PVC walls of the nest tubes probably prevented predation by woodpeckers. Both Albano (1992), who studied Carolina Chickadees, and Christman and Dhondt (1997), who studied Black-capped Chickadees, found that nests in cavities excavated in soft wood were more vulnerable to predation by woodpeckers than were nests in cavities excavated in wood that was not decayed. I conclude that the predation rate that I observed was unnaturally low and should not be used as an indicator of predation rates of Carolina Chickadee nests in natural cavities.

The definition I used for a nesting attempt, a constructed nest in which I saw at least one egg, may have resulted in the omission of some nesting data. Any nest in which both egg-laying was initiated and depredation occurred between my inspections would not have been included in my results as a nesting attempt unless the predator left egg shell fragments or other evidence of the eggs. For example, if a female chickadee laid the first egg in a nest and a few hours later a predator removed the egg, the female would probably have abandoned the nest. If I had not inspected the nest in the interval between egg-laying and predation, I would have concluded that the birds abandoned the nest before egg-laying began. While I cannot rule out this possibility, I think it is unlikely to have occurred very often. Based on the available evidence I concluded that none of the 12 nesting attempt failures that occurred during the egg-laying stage in this study were caused by predators. Mammalian predators such as raccoons and flying squirrels typically leave fragments of eggshells and other signs of nest disturbance (Pinkowski 1975) that would have allowed me to detect the presence of an egg. Rat snakes were the predators most likely to leave no obvious evidence of their depredation, but chickadees laid most of their eggs in the cool months before snakes actively search for nests (Stickel et al. 1980).

Nest failure due to weather. Inclement weather was the single largest cause of nest failure (Table 2). For example, in 1984 below normal air temperatures and above normal rainfall had a devastating effect on chickadee reproduction on my study sites (Table 1). During cool weather, the female chickadee must incubate the eggs and brood the young a larger percentage of the time in order to maintain optimal developmental temperature. At the same time, the foliage-devouring caterpillars that serve as a primary food source at this time of year (Pitts, personal observation) are (1) inactive (and therefore less likely to be detected by birds) due to the cool temperatures

and (2) not growing at their normal rate. In addition, (3) sometimes they are washed from the leaves by the rain and become inaccessible to the chickadees. Consequently, the female chickadee has less foraging time available, and probably a reduced foraging efficiency, during the cool, wet weather. This results in additional physiological stress on her and the eggs and young. Even though the male delivers some food to the female when she is incubating and brooding (Pitts, personal observation), this may be insufficient to meet her needs. The continued stress on the adults from the cool, wet weather may eventually cause the adults to abandon their nesting attempt in an effort to maintain their own lives. This "decision" may be hastened if the nestlings become chilled and are unable to beg for food.

One of the advantages of a long-term study is the increased possibility of detecting events, such as weather induced failures of nesting attempts, that may occur sporadically. Carolina Chickadees begin nesting activities in late winter or early spring and typically encounter inclement weather in the early stages of the nesting cycle. Constructing the nest in a cavity and lining the cavity with fur are two of the adaptations that enable chickadees to counter these challenges. When the eggs hatch and nestlings are being fed, typically in April, the milder environmental conditions that normally prevail are conducive to the growth of the insect populations that chickadees rely on when feeding the nestlings. However, as described above, if extended periods of cold, wet weather occur at this time, many of the nestlings may die. In most years, few if any of the nesting attempts failed because of the weather conditions. In his study in Illinois, Albano (1992) did not detect any nesting failures that he could attribute to weather. During the two years when his study was conducted, 1989 and 1990, nesting success was also high on my study sites. This contrasts with the results in cool, wet years such as 1983, 1984, and 1995 when a total (for the three years) of 234 eggs produced only 59 fledglings (Table 1) on my study sites. Adverse weather can cause failure in a high percentage of their nesting attempts, but Carolina Chickadees typically, but not always, avoid such failures.

Competition with other cavity nesting birds. The number of Carolina Chickadee nesting attempts in my nest structures varied widely with peak usage in 1979-1983 (Table 1). During this five-year period 38.3% of the nests reported in this study were built. This period coincided with a crash and recovery of the Eastern Bluebird population on the study sites (Figure 5) (Pitts 1981, 1984). Eastern Bluebirds will usurp active Carolina Chickadee nests (Table 2), but interactions between chickadees and bluebirds at contested nesting sites frequently occurred before the chickadees had laid any eggs (and thus could not be recorded as a nest failure in this study). At many nest boxes used by bluebirds, I had earlier observed chickadees investigating the nest box or had found an early stage of chickadee nest construction. Eastern Bluebirds typically weigh about 30 g at this time of year, compared

to 10-11 g for Carolina Chickadees (Pitts, personal observation). Contests between the two species are usually won by bluebirds. (I have no records of Eastern Bluebirds taking over a Carolina Chickadee nest that contained young. This absence of records could have resulted either from the chickadees being more aggressive in the defense of their nesting cavity during the nestling stage or from the bluebirds being less aggressive in their efforts to commandeer cavities containing nestlings.) These observations, combined with the documented loss of Carolina Chickadee nests to Eastern Bluebirds (Table 2), lead me to conclude that Eastern Bluebirds affected Carolina Chickadee nest box selection and nest success more than any other species of predator or competitor. This conclusion is probably to be expected since the nest boxes were designed for bluebirds and were located in bluebird habitat. None of the chickadee nests in PVC tubes (with entrances 3.2-cm in diameter, which chickadees, but not bluebirds, could enter) were usurped by bluebirds.

One of the disadvantages of the small body size of Carolina Chickadees is the high probability of losing fights with larger birds of other species. Such fights may occur inside cavities that each species attempts to claim for a nest site. While I found no evidence that Eastern Bluebirds killed Carolina Chickadees, I did find circumstantial evidence that indicates three other species of cavity nesting birds (Tufted Titmouse, House Sparrow, and Prothonotary Warbler) killed adult Carolina Chickadees at nest cavities. Carolina Chickadees could reduce the frequency of disputes over cavity ownership with Tufted Titmice and House Sparrows by either selecting or excavating nest cavities with small entrances that prevent these larger species from entering.

Prothonotary Warblers are slightly larger than Carolina Chickadees. Walkinshaw (1941) found Prothonotary Warblers in Tennessee to weigh about 15 g; the chickadees on my study sites typically weigh 10-11 g (Pitts, personal observation). Prothonotary Warblers can enter most of the nest cavities used by chickadees. The wet woodland habitat used for nesting by Prothonotary Warblers is used for nesting by chickadees (although chickadees also nest in dry upland woodlands that are not used by Prothonotary Warblers). Prothonotary Warblers are neotropical migrants that typically begin arriving on my Weakley County study site in late March; they have a long nesting season that begins in April and extends into late July (Pitts, personal observation). Competition from Prothonotary Warblers for nesting sites may be one of the factors that has resulted in Carolina Chickadees having such an early nesting season with relatively few second nesting attempts.

Rate of egg-laying. My observations strongly support the conclusion that female Carolina Chickadees normally lay their eggs at the rate of one per day on consecutive days until the clutch is completed. However, my data may not accurately indicate the frequency of irregular egg-laying (i.e., when an interval of more than one day occurs between the laying of consecutive

eggs). The two apparent cases of irregular egg-laying that I observed could have alternative explanations. For example, a female could have laid an egg at some location other than the nest cavity, possibly because of the presence of a predator near the nest at the time she normally deposited the egg. Or, the female might have removed an egg from the nest, as I observed at one chickadee nesting attempt during the incubation period. On the other hand, I suspect that I did not detect some cases of irregular laying because I did not inspect each of the nest boxes every day. For example, I had no way of knowing if irregular laying occurred at a nest where I found 2 eggs on one visit and a completed clutch of 5 eggs on my next visit four days later.

Clutch size. Brewer (1963) collected data from the literature, correspondence and his own notes on 45 clutches of Carolina Chickadees; the number of eggs per clutch ranged from 4 to 9 with a mean of 6.09 (calculated from his Table 15). Brewer (1963) found that clutches of 6 and 5 were most frequent, making up 35.5% and 31.1%, respectively, of the total. Mowbray and Goertz (1972) observed 54 complete Carolina Chickadee clutches which ranged in size from 3-6, with a mean of 4.6; they did not indicate the frequencies of various clutch sizes or a modal clutch size. Like Brewer (1963) I found clutches of 5 and 6 to be numerous, but unlike either Brewer (1963) or Mowbray and Goertz (1972) I commonly found clutches of 7 (Figure 1). Perrins and McCleery (1989) considered all clutches of 4 or less in Great Tits (*Parus major*) to be incomplete; I do not believe this is true for Carolina Chickadees. I found two late in the year clutches that consisted of only 2 eggs each; both clutches were incubated normally. At one of these nests both of the eggs hatched and produced fledglings while at the other nest 1 egg hatched and 1 young fledged. I also found clutches of 3 and 4 eggs where incubation and hatching were normal. Mowbray and Goertz (1972) did not find any clutches larger than 6; in my study clutches larger than 6 (i.e., 7 and 8) made up 23.3% of the total (Figure 1). I have insufficient data to support any hypothesis that explains why all of the clutches of 8 were laid in Obion County during the six year period of 1978-1983. While I suspect some relationship between the clutches of 8 and the record low numbers of Eastern Bluebirds which also occurred during this period, I doubt the explanation is simply the absence of Eastern Bluebirds. I also think it is premature to attribute the lack of clutches of 8 during the last 12 years of this study to global warming, although Carolina Chickadees are known to lay smaller clutches at lower (and warmer) latitudes (see below).

Factors influencing clutch size. In Table 4 I have summarized clutch size data from five studies of Carolina Chickadees. Like numerous other species in the Northern Hemisphere (Welty 1982), Carolina Chickadees show an increase in both mean clutch size and maximum clutch size from south to north in their breeding range. The cause of this gradient in clutch size has not been determined, but factors such as mortality, food availability, and day

Table 4. Relationship between latitude and clutch size in Carolina Chickadees.

LATITUDE	MEAN CLUTCH SIZE	MAXIMUM CLUTCH SIZE	SOURCE
32°	4.6	6	Mowbray and Goertz 1972
35-36°	5.7	8	Pitts 1997
36°	5.6	8	this study
37°	5.7	not given	Albano 1992
38-40°	6.8	9	Brewer 1963

length (all of which vary with latitude) are commonly thought to be involved (Welty 1982).

As in other parids (Perrins and McCleery 1989) and in numerous other species (Welty 1982), clutch size of Carolina Chickadees declined in the latter part of each nesting season. Clutches of 4 were laid over a greater span of time (13 March-28 May) than any of the other clutch sizes (Figure 3). Some of the clutches of 4 that were laid early in the nesting season may have been produced by females who were forced by cold weather or prolonged rains to prematurely terminate laying. It is possible that some of the early clutches of 4 were laid by young females. In many species, younger females lay smaller clutches (Perrins 1979). I was able to verify that only two of 64 banded females made more than one nesting attempt in a single season. However, I suspect that several of the clutches laid in the last part of the nesting season may have been replacement nests (following the loss of the first nest). Less commonly, they may have been second nesting attempts (following a successful first nesting attempt). Perrins and McCleery (1989) discussed several factors that influence clutch size; they concluded that the seasonal decline in clutch size is ultimately due to the lower success rate of late nesting attempts. Both early and late nesting attempts in my study were less successful than nesting attempts in the middle of the nesting season (Figure 4).

Nesting abnormalities. I suspect that the deposition of Carolina Chickadee eggs in sites such as a House Sparrow nest or a cavity with no nest material was due to disruption of the chickadee nest. The female chickadee may have completed the development of an egg and then discovered that her nest had been destroyed by a predator or was not accessible because a competitor had commandeered the cavity. She was then forced to lay the egg at some other site. Eggs laid in another cavity were not necessarily doomed to failure, as would be an egg that she deposited outside of a cavity, since female chickadees frequently added lining material to the nest cavity during the egg-laying stage and during the early stages of incubation. The probability is low that a female chickadee could find, in a period of only a few hours, a suitable nest cavity that was not occupied by some other animal; however, this would

occasionally occur. Placing into memory the location of alternate nest sites prior to the beginning of the nesting cycle is perhaps one of the advantages of inspecting many possible nest sites, or even of excavating more than one cavity.

The two cases of a chickadee laying an egg in the "wrong" cavity (i.e., a cavity other than the one in which the other eggs were laid) when given a choice of two nest cavities 75 cm apart were possibly due to confusion or forgetfulness. In both cases the female had carried nesting materials into each of the two adjacent cavities prior to selecting one. Female chickadees frequently did not finish construction of the nest prior to egg-laying so the absence of a complete nest in the "wrong" cavity would not signal to the female that she was not in the correct nest cavity. Perhaps more remarkable than the laying of two eggs in the "wrong" cavity is the fact that chickadees laid 109 other eggs in the "correct" cavity in the paired nest box tests.

A Carolina Chickadee nest with two nest cups was reported by Doherty and Condit (1994). They attributed both nest cups to one female. They described her behavior as "apparently aberrant" and suggested that the electromagnetic field from an overhead high-voltage transmission line might have influenced her behavior. The construction and use of multiple nest cups in one cavity by a single female would likely lead to the failure of at least part of the clutch, since she could not adequately incubate both groups of eggs. Doherty and Condit (1994) did not describe the dimensions of the nest box in which they observed two nest cups. However, based on the photograph published in their article and the mean length I found for Carolina Chickadee eggs (15.6 mm), I estimated the floor of the nest box to be about 115 mm x 100 mm. This is similar to the floor size of the nest box in which I observed two nest cups. I found that when given a choice, Carolina Chickadees prefer smaller nest cavities. Perhaps one of the advantages of smaller nest cavities is the reduced probability of multiple nest cups (and the accompanying high failure rate for at least part of the clutch) in the nest cavity.

Number of nesting attempts per year per chickadee. Brewer (1961) concluded that Carolina Chickadees rarely make a second nesting attempt following a successful nest earlier that year. My data support this conclusion; I observed only one such case in the 100 nesting attempts where I identified banded Carolina Chickadees. An advantage of producing multiple broods per year is a potential increase in the number of young fledged. The one chickadee pair that I observed with two successful nests fledged ten young in one nesting season; this was the largest number fledged in a single nesting season by any of the chickadee pairs that I studied. Presumably, other factors select against the chickadees that attempt a second nest during the same year in which they have already successfully fledged a brood.

Albano (1992) stated that Carolina Chickadees "... rapidly renest following nest destruction." My data do not support this statement. Following the 20 failed nesting attempts where I had identified either one or both of the

banded adults, I documented only one case of renesting by these banded birds. At the 12 nesting attempts where the first egg was laid on or after 1 May (and which, based on the date, might be renesting attempts), I documented two second nesting attempts for a year; one followed an earlier successful nest and the other followed a nest loss. While I suspect that some of the other late season nesting attempts that I observed may also have been renesting attempts, they could have been first nesting attempts of the year by pairs that did not have access to suitable nesting sites earlier in the year.

If they survive uninjured, Carolina Chickadees may be more likely to make renesting attempts following the loss of a nest to predators than following the loss of the nest because of climatic conditions. Pairs of chickadees that abandoned their nests due to weather conditions (a major cause of failure; Table 2) may not have been inclined to renest because of their poor body condition, continued unfavorable weather, or diminished food supplies as a result of the weather. Due to the small number of nests lost to predators on my study areas (Table 2), I had few opportunities to observe renesting attempts following nest loss due to predation.

I do not understand the basis for Albano's (1992) statement that Carolina Chickadees "rapidly" renest following the loss of their first nesting attempt of the season. This implies that they normally renest following disruption of their first nesting attempt. Albano (1992) did not mention the use of bands or other methods to individually recognize the Carolina Chickadees that he studied; apparently he did not document renesting in his study. The only justification he gives for his statement about renesting is a citation of Brewer (1961). While Brewer (1961) did mark "a few" of the chickadees he studied, his only comment about renesting is the rather vague statement that he had "...found instances of what appeared to be re-nesting following some kind of interference with the first nesting." This is certainly not a data summary statement that establishes renesting as a common occurrence. While I believe that Albano (1992) did not have adequate justification for stating that Carolina Chickadees rapidly renest, I suspect that his inference may be correct, at least for some situations. As the one case I described above indicates, Carolina Chickadees will sometimes renest following nest loss. However, the frequency and timing of renesting and the effects of circumstances, such as the cause of nest loss, on renesting are not adequately documented. Generalizations at this point would be premature.

Survival of adults, mate retention, and nest site reuse. The longest documented life of a Carolina Chickadee is 10 years and 11 months (Clapp et al. 1983). The oldest banded Carolina Chickadee on my study area (in Weakley County) lived through 10 winters. These extremes are atypical and certainly do not accurately describe the average life span of most Carolina Chickadees. The mortality rate for juveniles is extremely high (Smith 1991). During the first few months following fledging, more than 75% of the

juveniles probably die, although this number varies annually and is difficult to accurately determine because of the movement of juveniles away from the nesting areas. Of the small number of Carolina Chickadees that reached breeding age (approximately 1 year old) on my study sites, about 65% of them disappeared (and presumably died) after one nesting season. The oldest chickadee that used my nesting structures survived through five nesting seasons. If we assume that the number of nesting seasons a chickadee was present accurately indicates its length of life, the average longevity of 64 females was 1.42 years and the average longevity of 48 males was 1.46 years. The 112 adults of both sexes combined had an average longevity of 1.44 years. These calculations are biased because (1) the huge majority (probably more than 75%) of the chickadees that hatch do not survive long enough to breed, (2) some of the chickadees could have been more than one year old when they first used my nesting structures, and (3) other chickadees may have survived longer than indicated by their use of my nesting structures. A study of survival and longevity in Black-capped Chickadees in Missouri based on recaptures and sightings at feeders found an average survival age of about 2.5 years (Elder and Zimmerman 1983). I am not aware of any comparable studies of Carolina Chickadees.

The primary factor that caused Carolina Chickadees on my study sites to change mates was the disappearance of their previous mates. In most cases the disappearing mate probably died, although in some instances both members of the original pair survived and obtained new mates. Otter and Ratcliffe (1996) found that female Black-capped Chickadees will desert their mates in order to pair with males of higher social rank. This type of behavior may explain some of the mate changes that I observed in Carolina Chickadees.

Most of the changes of nest sites that I documented involved movement of adult chickadees to nearby sites. Since many of the nesting structures that I provided were only 50 to 100-m apart, it is likely that some chickadee territories included more than one of these nesting structures. Consequently, nest site changes did not necessarily indicate changes in the size or boundaries of territories or establishment of a new territory. Since I did not plot territory boundaries and determine the size and shape of the territories, I think it would be inappropriate for me to speculate further on the relationship between territory characteristics and nest site and mate fidelity.

Banded fledglings that later nested on the study areas. Greenwood and Harvey (1982) noted that natal dispersal (which they defined as movement from the site of hatching to the site of first reproduction) was difficult to measure, partly because of the high mortality of juveniles. I assumed that the survival rate of fledgling Carolina Chickadees on my study sites was higher than indicated by my identification as nesting adults of only six of the 467 banded nestlings. Several factors, in addition to mortality, may have influenced the number of banded nestlings that I subsequently identified as

adults. (1) I identified only about 40% of the adults that made nesting attempts in the nesting cavities I monitored. In some years, especially 1979-1983 and 1992-1995, I identified most of the adults that made nesting attempts, but in other years I identified few or even none of the adults. Possibly some of these unidentified adults had been banded as nestlings on the study sites. (2) If the Carolina Chickadees on my study sites dispersed as far as Black-capped Chickadees (2.3 km for females and 1.3 km for males) (Robbins et al. 1986), most of the surviving fledglings would have moved off of my study sites. (3) The shapes of my study sites (long and narrow in Obion County; isolated farms in Weakley County) were not conducive to a study of natal dispersal which is apparently random in direction (Weise and Meyer 1979). (4) Eastern Bluebirds monopolized most of the nesting cavities I provided (especially during 1970-1991); this may have forced dispersing chickadees to use natural cavities, which would have prevented me from identifying banded birds since I did not search for nests in natural cavities. (5) Some (possibly most?) Carolina Chickadees prefer natural nest cavities rather than the artificial cavities I provided.

Blowflies. The largest number of immature bird blow flies that I found in one nest (94) is smaller than the maximum number (149) that Sabrosky et al. (1989) reported for Carolina Chickadees. Gold and Dahlsten (1983) also reported larger numbers (maximum = 273) of bird blow flies in nests of Chestnut-backed Chickadees (*Poecile rufescens*) and Mountain Chickadees (*Poecile gambeli*) using nest boxes in California. Gold and Dahlsten (1983) found that the percentage of parasitized nests varied with habitat; more than 90% of the chickadee nests they studied in an interior forest were parasitized but less than 2% of the nests in a coastal area were parasitized. I found that similar percentages of the Carolina Chickadee nests on my Obion County (62.0%) and Weakley County (75.0%) study sites were parasitized, perhaps because of habitat similarities.

Since *Protocalliphora* larvae are obligatory bloodsucking parasites, the presence of large numbers of larvae in a nest would seem to be detrimental to the nestling chickadees. "Parasitized nests had a significantly larger number of hatching eggs (5.2 vs. 4.4 in non-parasitized nests), but parasitized nests did not have a significantly larger number of fledglings (4.3 vs. 3.9 in non-parasitized nests. I suspect that blow fly larvae were responsible, at least in part, for the higher losses of nestlings in the parasitized nests." Unlike Perrins (1979), I did not find more immature blow flies in the nests with larger broods. Bird blow flies do not normally kill young birds (Perrins 1979) but may weaken them and make them susceptible to other factors, such as inclement weather (Sabrosky et al. 1989). Hurtrez-Bousses et al. (1997) found that large numbers of *Protocalliphora* reduced nestling body mass and hematocrit levels in Blue Tits (*Parus caeruleus*). Hurtrez-Bousses et al. (1997), like Gold and Dahlsten (1983), concluded that although heavy

loads of *Protocalliphora* did not affect the survival of nestlings to the time of fledging, the effects of the parasites might reduce post-fledging survival.

The stimulus that attracts bird blow flies to chickadee nests has not been identified. Neither is the time of egg deposition by female bird blow flies known. Sabrosky et al. (1989) suggested that a chemical released by the hatching bird eggs or by the recently hatched young could serve as an attractant to female bird blow flies. My observation that parasitized Carolina Chickadee nests had a significantly larger number of hatching eggs (mean = 5.2) than non-parasitized nests (mean = 4.4), but not a significant difference in clutch size, supports the suggestion of Sabrosky et al. (1989) that a chemical released at hatching attracts blow flies.

I assumed, but did not verify, that all of the bird blow flies that I observed were *Protocalliphora deceptor*. Sabrosky et al. (1989), while noting that some species of birds are parasitized by several species of bird blow flies, had records of only one species, *Protocalliphora deceptor*, from Carolina Chickadee nests.

ACKNOWLEDGMENTS

I thank J. D. Joslin, C. P. Nicholson, C. R. Blem, and two anonymous reviewers for their numerous and constructive comments on the manuscript.

LITERATURE CITED

American Ornithologists' Union. 1983. *Check-list of North American Birds, sixth ed.* Washington, D. C., Am. Ornithol. Union.

American Ornithologists' Union. 1997. Forty-first Supplement to the American Ornithologists' Union Checklist of North American Birds. *Auk* 114:542-552.

Albano, D. J. 1992. Nesting mortality of Carolina Chickadees breeding in natural cavities. *Condor* 94:371-382.

Bent, A. C. 1964. *Life Histories of North American Jays, Crows, and Titmice.* Part II. Dover Publications, Inc., New York, New York.

Brewer, R. 1961. Comparative notes on the life history of the Carolina Chickadee. *Wilson Bull.* 73:248-373.

Brewer, R. 1963. Ecological and reproductive relationships of Black-capped and Carolina Chickadees. *Auk* 80:9-47.

Christman, B. J., and A. A. Dhondt. 1997. Nest predation in Black-capped Chickadees: how safe are cavity nests? *Auk* 114:769-773.

Clapp, R. B., M. K. Klimkiewicz, and A. G. Futcher. 1983. Longevity records of North American birds: Columbidae through Paridae. *J. Field Ornithol.* 54:123-137.

Conner, R. N. 1974. Red-bellied Woodpecker predation on nestling Carolina Chickadees. *Auk* 91:836.

Dixon, K. L. 1963. Some aspects of social organization in the Carolina Chickadee. Proc. XIIIth Internatl. *Ornithol. Congr.*:240-258.

DOHERTY, P. F., Jr., and J. M. Condit. 1994. Carolina Chickadee lays and incubates eggs in two separate nest cups within the same nest box. *Wilson Bull.* 106:569-571.

DRURY, W. H. 1958. Chickadees and nest boxes. *Mass. Aud. Soc. Bull.*, Nov., p.1.

ELDER, W. H., and D. ZIMMERMAN. 1983. A comparison of recapture versus resighting data in a 15-year study of survivorship in the Black-capped chickadee. *J. Field Ornithol.* 54:138-145.

GOLD, C. S., and D. L. DAHLSTEN. 1983. Effects of parasitic flies (*Protocalliphora spp.*) on nestlings of Mountain and Chestnut-backed Chickadees. *Wilson Bull.* 95:560-572.

GREENWOOD, P. J., and P. H. HARVEY. 1982. The natal and breeding dispersal of birds. *Ann. Rev. Ecol.* Syst. 13:1-21.

GREENWOOD, P. J., P. H. HARVEY, and C. M. PERRINS. 1979. The role of dispersal in the great tit (*Parus major*): the causes, consequences and heritability of natal dispersal. *J. Anim. Ecol.* 48:123-142.

HURTREZ-BOUSSES, S., J. BLONDEL, and P. PERRET. 1997. Relationship between intensity of blowfly infestation and reproductive success in a Corsican population of Blue Tits. *J. Avian Biology* 28:267-270.

KILHAM, L. 1983. Life History Studies of Woodpeckers of Eastern North America. *Publ. Nuttall Ornithol.* Club 20. Cambridge, Massachusetts. 240 pp.

KLUYVER, H. N. 1961. Food consumption in relation to habitat in breeding chickadees. *Auk* 78:532-550.

LAWRENCE, L. DE K. 1967. A comparative life-history study of four species of woodpeckers. *Ornithol. Monogr.* No. 5.

MCCAMEY, R. 1961. The chickadee trap. *Bird-Banding* 32:51-55.

MOWBRAY, E. E., and J. W. GOERTZ. 1972. Nesting season and reproductive rates of cavity nesting birds of north Louisiana. *Southwest. Nat.* 17:145-151.

ODUM, E. 1942. Long incubation by a Carolina Chickadee. *Auk* 59:430-431.

OTTER, K., and L. RATCLIFFE. 1996. Female initiated divorce in a monogamous songbird: abandoning mates for males of higher quality. *Proc. Royal Society London (Series B Biol. Sci.)* 263:351-355.

PERRINS, C. M. 1979. *British Tits.* Collins, London, England.

PERRINS, C. M., and R. H. MCCLEERY. 1989. Laying dates and clutch size in the Great Tit. *Wilson Bull.* 101:236-253.

PINKOWSKI, B. C. 1975. A summary and key for determining causes of nesting failures in Eastern Bluebirds using nest boxes. *Inland Bird Banding News* 47:179-186.

PITTS, T. D. 1976a. Fall and winter roosting habits of Carolina Chickadees. *Wilson Bull.* 88:603-610.

PITTS, T. D. 1976b. *Nesting Habits of Eastern Bluebirds in Northwest Tennessee.* Dissertation, Univ. Tennessee, Knoxville.

PITTS, T. D. 1978. Some nesting habits of Carolina Chickadees. *J. Tenn. Acad. Sci.* 53:14-16.

PITTS, T. D. 1981. Eastern Bluebird population fluctuations in Tennessee during 1970-1979. *Migrant* 52:29-37.

PITTS, T. D. 1984. Historical population changes of Eastern Bluebirds in northwest Tennessee. *Sialia* 6:43-47.

PITTS, T. D. 1988. Effects of nest box size on Eastern Bluebird nests. *J. Field Ornithol.* 59:309-313.

PITTS, T. D. 1992. Reproduction of southern flying squirrels (*Glaucomys volans*) in Weakley County, Tennessee. *J. Tenn. Acad. Sci.* 67:81-83.

PITTS, T. D. 1997. Carolina Chickadee, pp. 219-221 in Nicholson, C. P. 1997. *Atlas of the Breeding Birds of Tennessee*. Univ. Tennessee Press, Knoxville. 426 pp.

POTTER, E. F. 1976. A case of suspected double-broodedness in the Carolina Chickadee. *Chat* 40:97-98.

ROBBINS, M. B., M. J. BRAUN, and E. A. TOBEY. 1986. Morphological and vocal variation across a contact zone between the chickadees *Parus atricapillus* and *P. carolinensis*. *Auk* 103:655-666.

SABROSKY, C. W., G. F. BENNETT, and T. L. WHITWORTH. 1989. *Bird blow flies (Protocalliphora) in North America (Diptera: Calliphoridae), with notes on the Palearctic species*. Smithsonian Inst. Press, Washington, D. C. 312 pp.

SAS INSTITUTE. 1995. *JMP statistics and graphics guide*. SAS Inst. Inc., Cary, North Carolina.

SMITH, S. M. 1991. *The Black-capped Chickadee: behavioral ecology and natural history*. Cornell Univ. Press, Ithaca, NY. 362 pp.

SMITH, S. T. 1972. *Communication and other social behavior in Parus carolinensis*. Publ. Nuttall Ornithol. Club 11. Cambridge, Massachusetts. 125 pp.

STICKEL, L. F., W. H. Stickel, and F. C. Schmidt. 1980. Ecology of a Maryland population of black rat snakes *(Elaphe o. obsoleta)*. *Am. Midl. Nat.* 103:1-14.

TANNER, J. T. 1952. Black-capped and Carolina Chickadees in the southern Appalachian Mountains. *Auk* 69:407-424.

WALKINSHAW, L. H. 1941. The Prothonotary Warbler, a comparison of nesting conditions in Tennessee and Michigan. *Wilson Bull.* 53:3-21.

WEISE, C. M., and J. R. MEYER. 1979. Juvenile dispersal and development of site-fidelity in the Black-capped Chickadee. *Auk* 96:40-55.

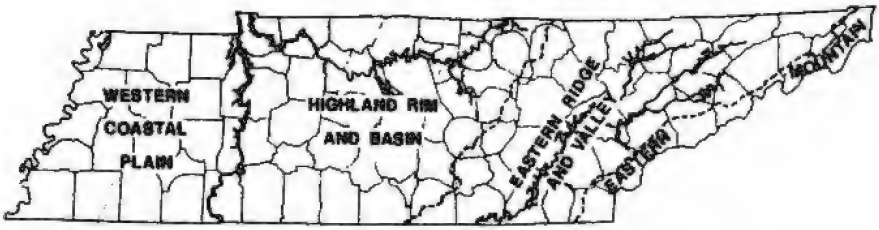
WELTY, J.C. 1982. *The Life of Birds* (Third edition). CBS College Publishing, Philadelphia.

WOOD, J. T., and S. I. LUSTICK. 1989. The effects of artificial solar radiation on wind-stressed tufted titmice (*Parus bicolor*) and Carolina chickadees (*Parus carolinensis*) at low temperatures. *Comp. Biochem. Physiol. A: Comp. Physiol.* 92:473-478.

The Migrant, 69 (2): 105-114, 1998.

THE SEASON

Richard L. Knight, EDITOR



Winter: 1 December 1997 - 28 February 1998

As a result of a strong El Nino / Southern Oscillation weather phenomenon in the eastern Pacific Ocean, the southeastern U.S. experienced a rather mild winter, with most of Tennessee also slightly wetter than average. The mild conditions apparently allowed several species to linger later than usual in all regions; however, few of these birds remained beyond the Christmas Bird Count period. Or did birding away from feeders just diminish? A few early spring migrants appeared in late February, probably encouraged by the continuing mildness. Most notable among these were Tree Swallows in three regions.

Separate snowstorms dumped significant accumulations in northeast Tennessee in late January and the Cumberland Plateau in early February. The most visible impact was on vegetation, but ground feeding birds surely suffered.

The irruptive movements of boreal finches and Red-breasted Nuthatches are thought to be governed by food availability rather than by weather. Autumn 1997 provided the hint of a good flight of these invaders, but this generally failed to occur. Nuthatches were the exception, being widespread in fair to good numbers; however, finches were sparsely scattered. Still, this was a better flight than in some years. A White-winged Crossbill at Nashville was extraordinary. This species staged a major flight in some areas north of Tennessee.

Other notable rarities included Calliope Hummingbird, Prairie Falcon, Ross' Goose, Red Phalarope, and Red-throated Loon.

Standard Abbreviations

* - documentation provided
ad - adult
CBC - Christmas Bird Count
Co. - County
et al. - and others
f - female
im - immature
L. - Lake
m - male
max - maximum one day count
m.ob. - many observers
NWR - National Wildlife Refuge
R. - River
S.P. - State Park
WMA - Wildlife Management Area

WESTERN COASTAL PLAIN: Is it possible that El Nino created the unusual weather patterns that would lure summer residents, such as Great Egret, Lesser Yellowlegs, and Gray Catbird, to linger? And could the weather have also attracted Oldsquaw, Common Merganser, Greater Scaup and 24 other waterfowl species to area lakes? Did the same weather patterns create the favorable conditions for the appearance of the Snow Bunting, Pine Siskin, and Purple Finch? Did the same mild weather influence record numbers of Sandhill Cranes to spend their third winter at Hop-In WMA? Fifty-two observers enjoyed the above normal temperatures and weathered the above normal rainfall to record this unusual mix of summer resident layovers and winter visitors.

Grebe - Merganser: **Horned Grebe:** 20 Dec - 19 Feb (18 max) Reelfoot L. (MAG, WGC); 28 Feb (1) Robco L., Shelby Co. (MAG, JRW). **Red-necked Grebe:** 20 Dec (2) Reelfoot CBC (MAG, JRW *et al.*). **American White Pelican:** 31 Jan - 28 Feb (150+ max) Reelfoot L. (WGC, MAG, JRW); 23-24 Feb (100) Dyer Co. (WGC). **Double-crested Cormorant:** 26 Dec - 23 Feb (300 max) Reelfoot L. (WGC); 3 Feb (15) Chickasaw NWR (CHB, VBR). **American Bittern:** 21 Feb (1) Hardin Co. (SNM, GCP, DJT *et al.*), second Co. record. **Great Egret:** 2 Dec (1) Heloise (WGC); 13 Dec (1) Gibson Co. (MAG); 26 Feb (1) Airpark Rd., Reelfoot L. (Nancy Moore). **Mute Swan:** 13 Dec (2) Gibson Co. (MAG); 21 Dec (4) Memphis CBC; 18 Feb (2) Kennedy Park, Memphis (CHB, SCF, VBR, BHW). **Greater White-fronted Goose:** 16 Dec (7) Lauderdale WMA, 4 Dec - Feb (800 max) Lake Co. (WGC). **ROSS' GOOSE:** 21/24 Jan (11) Black Bayou WMA (WGC); 24 Jan (2) Lauderdale WMA (MAG, JRW). **Greater Scaup:** 2/15 Dec (5) Heloise (WGC); 13 Dec (3) Gibson Co. (MAG); 20 Dec / 24 Jan (2) Tiptonville Lagoon, Lake Co. (MAG, JRW); 3 Feb (2) Chickasaw NWR (CHB, VBR); 4 Feb (2) Shelby Farms, Shelby Co. (FCP, BFP); 8 Feb (6) TVA Lake (MAG, WRP, JRW). **Oldsquaw:** 21 Jan / 8 Feb (2) TVA Lake (CHB, SCF, RLJ, GLI, WRP, VBR, BHW). **Common Merganser:** 8 Feb (2) TVA Lake

(GLI, RLI). **Red-breasted Merganser:** 13/24 Feb (10) Everett L. (WGC); 28 Feb (5) Reelfoot L., Obion Co. portion (MAG, JRW).

Vulture - Crane: **Turkey Vulture:** 21 Dec (1) Memphis CBC; 22 Dec (4) Shelby Co. (SRM); 28 Dec (6) Shelby Co. (CHB, SRM, GCP). **Black Vulture:** 28 Dec (5) Shelby Co. (CHB, SRM, GCP). **Bald Eagle:** 5 Dec - Feb (nest) Heloise (WGC); 19 Dec (1 ad, 1 im) Lauderdale WMA; 3 Jan (2 im) Chickasaw NWR (CHB, VBR); 22 Jan (nest) L. Isom, Lake Co.; 13 Feb (nest) Lake # 9, KY / TN line, new nest south of old nest (WGC); 21 Feb (1 ad) Hardin Co. (TOS). **Sharp-shinned Hawk:** (1) Tipton, (2) Shelby, (1) Madison, (1) Fayette, (1) Hardin, (1) Gibson, (1) Haywood Cos. **Cooper's Hawk:** (12) Shelby, (2) Fayette, (2) Hardin, (3) Madison, (1) Lake Cos. **Red-tailed Hawk:** 19 Jan (1) Memphis (OKM), hit by car, non-releasable, had been banded June 1996 in Edmonton, Alberta. **Merlin:** 2 Jan (1) Savannah CBC (Steve & Sean McConnell). **PRAIRIE FALCON:** 16-17 Dec (1) Long Point, Reelfoot L., KY / Phillipy Pits, Lake Co., TN (Brainard Palmer-Ball, David Roemer), third record for Lake Co. **Peregrine Falcon:** 21 Feb (1) Pickwick SP (TOS). **Sandhill Crane:** 1 Jan (1) Gray's Camp, Reelfoot L., 3-26 Jan (37 to 361) Hop-In WMA, Obion Co. (WGC, Jim Johnson).

Yellowlegs - Nighthawk: **Lesser Yellowlegs:** 2 Dec (1) Heloise (WGC); 20 Dec (1) Reelfoot CBC. **Least Sandpiper:** 14 Dec (60) nw Memphis (LCC, MaH); 21 Dec (75) Memphis CBC; 5/19 Dec (130 max) Heloise (WGC); 7 Feb (22) EARTH Complex , Shelby Co. (VBR). **Spotted Sandpiper:** 21 Dec (1) Memphis CBC (Linda Zempel, Rob Peeples), third CBC record there. **Dunlin:** 2/15 Dec (24 max) Heloise (WGC). **American Woodcock:** 19 Dec (1) Black Bayou WMA (MAG); 2 Jan - 22 Feb (6+) Hardin Co. (TOS); 3 Jan - Feb (3) Wolf River WMA (SNM, MGW); 17 Jan (2) n Memphis (James Ferguson, SCF); 15-28 Feb (6+) Millington Airfield (CHB, DDP, GCP, VBR). **Barn Owl:** 15 Jan (1) e Shelby Co. (OKM); 19 Jan - Feb (1) Wolf River WMA (FCP, BTP, MGW); 24 Jan (1) Ridgely, Lake Co. (MAG). **Short-eared Owl:** 2 Jan (2) Savannah CBC; 20 Dec / 28 Jan (6 max) Black Bayou WMA (MAG, JRW); 25 Jan - Feb (7 max) Wolf River WMA (MTOS). **Common Nighthawk:** 6 Jan (2) e Memphis (CHB, MGW).

Crow - Siskin: **American Crow:** 27 Dec (20,000+) Jackson CBC. **Fish Crow:** 5 Dec (1) Heloise (WGC); 27 Dec (2) Jackson CBC; 24 Feb (2) Everett L. (MAG, JRW); 28 Feb (1) e Memphis (VBR). **Brown-headed Nuthatch:** 21 Feb (2+) Pickwick / Corps of Engineers Campground, Hardin Co. (TOS). **House Wren:** 20 Dec (1) Reelfoot CBC, Obion Co.; 3 Jan (2) Fayette CBC (MTOS). **Sedge Wren:** 20 Dec (2) Reelfoot CBC; 2 Jan (1) Savannah CBC; 15 Feb (1) Millington Airfield (Van Harris, DDP). **Marsh Wren:** 2 Jan (2) Savannah CBC. **Gray Catbird:** 2 Jan (1) Savannah CBC. **American Pipit:** 5/15 Dec (1) Heloise (WGC); 2 Jan (400+) Hardin Co. (MAG). **Orange-crowned Warbler:** 19 Dec (1) Reelfoot L. (MAG). **Palm Warbler:** 2 Jan (1) Savannah CBC. **American Tree Sparrow:** 20 Dec / 13

Feb (15 max) Reelfoot L. (MAG, VBR). **LeConte's Sparrow:** 7 Dec (1) Wolf River WMA (SNM, MGW); 20 Dec (9) Reelfoot CBC; 3 Jan (1) Fayette CBC; 2 Jan (12) Savannah CBC; 15 Feb (2) Millington Airfield (MTOS); 21 Feb (3) Hardin Co. (DDP, TOS). **Lapland Longspur:** 20 Dec (67) Reelfoot CBC. **Snow Bunting:** 20 Dec (1) Reelfoot CBC (MAG, JRW). **Western Meadowlark:** 13 Dec (3) Gibson Co. (MAG); 24 Jan (1) Dyer Co. (MAG, JRW). **Brewer's Blackbird:** 3 Jan (3) Fayette CBC; 28 Feb (1) Black Bayou WMA (MAG, JRW). **Purple Finch:** 13/17 Dec (1) Coffey Grounds, Memphis (LCC, MaH); 20 Dec (1) Reelfoot CBC; 21 Dec (40) Memphis CBC; 27 Dec (2) Jackson CBC; 2 Jan (4) Savannah CBC; 3 Jan (16) Fayette CBC; 16 Jan (2) Brunswick, Shelby Co. (GCP); 21 Feb (2) Pickwick SP (TOS); 22 Feb (41) Shiloh NMP, Hardin Co. (TOS). **Pine Siskin:** first week of Dec (12 max) Cypress Creek, near Pickwick SP (Joyce North); 20 Dec (12) Reelfoot CBC; 27 Dec (2) Jackson CBC; 3 Jan (3) Fayette CBC; 21 Feb (18+) Pickwick SP(TOS); 22 Feb (24) Shiloh NMP, Hardin Co. (TOS).

Locations: Black Bayou WMA - in Lake Co.; Chickasaw NWR - in Lauderdale Co.; Everett L. - in Dyer Co.; Heloise - in Dyer Co.; Lauderdale WMA - in Lauderdale Co.; Millington Airfield - in Shelby Co.; Pickwick SP - in Hardin Co.; Reelfoot L. - in Lake & Obion Cos.; TVA Lake - in Shelby Co.; Wolf River WMA - in Fayette Co.

MARTHA G. WALDRON, 1626 Yorkshire Drive, Memphis, TN 38119.

HIGHLAND RIM AND BASIN REGION: In Nashville the mean temperature for December was essentially normal. The effects of El Nino were felt during the first two months of 1998, however, as January and February were 9 and 6 degrees warmer than normal, respectively. Rainfall was 2 inches below average. As might be predicted from the above average temperatures, significant snowfall was scarce, with only 2.7 inches falling during two days in late December and 1.4 inches arriving during two days in early January. In the eastern part of the region, Cookeville was generally warm as well, but with average rainfall.

While the number of unusual species was small, the presence of five hummingbirds in the greater Nashville / middle Tennessee area made this a spectacular winter. Several of these hummingbirds were first observed in the fall, but not positively identified until they were banded in early December by Bob and Martha Sargent. Foremost among the impressive list was a female Calliope Hummingbird, a first state record.

The invasion of northern finches, anticipated by precursors in late fall, did not completely materialize. The major boreal invader in middle Tennessee was the Red-breasted Nuthatch. It was found in good numbers wherever there were pine trees, as well as at many feeders. Pine Siskins, Evening Grosbeaks and Purple Finches were spotty at best. A lone boreal visitor did create extensive interest, however: a White-winged Crossbill was seen for a

few days coming to a feeder in the Bellevue section of Nashville.

Loon - Crane: **Common Loon:** 21 Nov - 18 Dec (1) Radnor L. (FCF, *et al.*). **Horned Grebe:** 21 Feb (350+) Center Hill L., DeKalb Co. (SJS); 21 Feb (300) Woods Res. (BHS, SJS). **Great Blue Heron:** 24 Feb (75 in rookery) Old Hickory L. (Richard Newton). **Black-crowned Night-Heron:** 6 Dec (2) Old Hickory L. (NTOS). **Tundra Swan:** 18 Jan (1) Cross Creeks NWR, Stewart Co. (NTOS). **Greater White-fronted Goose:** 7 Feb (40) Duck R. Unit (CAS); 17 Feb (1) Radnor L. (Hope Murray). **Redhead:** Jan - Feb (3 m, 4 f) Ruth. Co. (TJW); 21 Feb (15) Woods Res. (SJS). **Greater Scaup:** 1 Jan (15) Old Hickory L. (CAS). **Hooded Merganser:** 10 Dec (253) Franklin Reservoir, Williamson Co. (Elizabeth O'Connor). **Ruddy Duck:** 6 Dec (23) Old Hickory L. (NTOS). **Bald Eagle:** 8 Feb (10) Duck R. Unit (CAS), max. **Cooper's Hawk:** 25 Feb (1) Cookeville (GKE), performing nuptial flight near site of 1996 nest. **Peregrine Falcon:** 5 Dec (1) Pennington Bend (MLM). **Sandhill Crane:** 1 Dec (54/60) Putnam Co. (David Sugeno / Amy Mercer); 14-15 Feb (many flights numbering hundreds of birds) Cookeville (Kenneth Morgan, Winston Walden *et al.*); 20 Feb (2) Nash (Jenny Nehring); 21 Feb (300) Putnam Co. (GKE); 25 Feb (800) Cookeville (David Sugeno); 28 Feb (2) Warren Co. (N.P. McWhirter).

Sandpiper - Wren: **Least Sandpiper:** 8 Feb (10) Duck R. Unit (CAS). **American Woodcock:** 6 Jan (2) Radnor L. (Lynn Ann Welsh). **Ring-billed Gull:** 15 Dec (1000) Old Hickory L. (CAS), max. **Herring Gull:** 7 Jan (100) Pennington Bend (MLM), max. **Glaucous Gull:** 1 Jan (1) Pennington Bend (MLM), seen with Herring Gulls. **Great Horned Owl:** 25 Feb (1 ad, 2 young in nest) Cookeville (GKE, SJS). **Ruby-throated Hummingbird:** 1 Dec into Jan (1 im f) Nash (William Midgett, RRS, MBS, m.ob.), probably hatched in Sept., banded 3 Dec. **BLACK-CHINNED HUMMINGBIRD:** thru 24 Feb (1 im f) Franklin (Fred & Pat Farley, RRS, MBS, m.ob.), banded 14 Dec. **CALLIOPE HUMMINGBIRD:** thru 15 Feb (1 im f) Nash (Ed & Evelyn Wright, RRS, MBS, m.ob.), banded 3 Dec, FIRST STATE RECORD. **Rufous Hummingbird:** thru 1 Mar (1 im m) Franklin (Martin & Dolores Gensci, RRS, MBS, m.ob.), banded 14 Dec; thru Jan (1 im m) Lebanon, Wilson Co. (R. & Geven Davis, RRS, MBS, m.ob.), banded 14 Dec. **Tree Swallow:** 28 Feb (10) Duck R. Unit (MLB, GAF, JeS); 28 Feb (6) AEDC, Coffee Co. (NTOS). **Red-breasted Nuthatch:** 20 Dec (19) Cookeville CBC, max. **Bewick's Wren:** 28 Jan (1) near Nolensville, Davidson Co. (Richard Connors); 31 Jan (1) Fork Springs Rd., Wilson Co. (TJW); both singing. **Winter Wren:** 30 Jan (8) Calfkiller R., White Co. (BHS, SJS), by canoe. **Sedge Wren:** 15 Dec (2) Shelby Bottoms (PDC).

Waxwing - Grosbeak: **Cedar Waxwing:** 17 Feb (25) Pennington Bend (MLM), max. **Blue-headed Vireo:** 21 Feb (1) Putnam Co. (Richard Simmers), first Co. winter record, but possibly an early migrant. **Orange-crowned Warbler:** 12-21 Dec (1) Shelby Bottoms (PDC); 20 Dec (1)

Cookeville CBC (BHS, Linda Perry), first Putnam Co. winter record; 3 Jan (1) Nash (MLB). **Palm Warbler:** 20 Dec (1) Cookeville CBC (Joanne Schaefer), first Putnam Co. winter record. **American Tree Sparrow:** 2 Dec (1) Franklin (Andrew Matthews). **Vesper Sparrow:** 28 Feb (1) Duck R. Unit (MLB, GAF, JeS); 28 Feb (3) Woods Res. (NTOS). **LeConte's Sparrow:** 7 Feb (2) Duck R. Unit (CAS). **White-crowned Sparrow:** 28 Feb (20) Duck R. Unit (MLB, GAF, JeS). **Dark-eyed (Pink-sided) Junco:** 21 Jan (1) Ruth. Co. (TJW). **Rusty Blackbird:** 1 Jan (200+) Old Hickory L. (CAS), max. **WHITE-WINGED CROSSBILL:** 8-9, 21-22 Dec (1 m) Nash (Kim Phillips, CAS, FCF, Drake Caldwell, m.ob.), sporadically at feeder & feeding on Crepe Myrtle. **Pine Siskin:** 1 Jan (4) Radnor L. (FCF, Joe Francis). **Evening Grosbeak:** 2 Dec (1) Nash (Cathy Shaw).

Locations: Duck R. Unit - part of Tennessee NWR, Humphreys Co.; Franklin - in Williamson Co.; Nash - Nashville; Old Hickory L. - in Sumner & Davidson Cos.; Pennington Bend - in Davidson Co.; Radnor L. - in Davidson Co.; Ruth. Co. - Rutherford Co.; Shelby Bottoms - in Davidson Co.; Woods Res. - Woods Reservoir, Franklin Co.

FRANCIS C. FEKEL, 8612 Sawyer Brown Road, Nashville TN 37221.

CUMBERLAND PLATEAU / RIDGE AND VALLEY REGION: Mild temperatures prevailed this winter, with just a couple of cold snaps interspersed. Precipitation varied only slightly from normal. A major snowstorm deposited 12-20 inches of heavy, clinging snow in northeast Tennessee on 27 January. A week later the Cumberland Plateau received 12+ inches of snow. Tree damage, especially to conifers, was extensive in both areas.

Doubtless due to the mild conditions, several species lingered later than usual; but, few of these remained into January. Autumn's hint of a boreal finch flight generally fizzled, except in the Chattanooga area. Waterfowl numbers were low. Notable rarities included Red-throated Loon, Ross' Goose, Rough-legged Hawk, Red Phalarope, and American Tree Sparrow. A couple of early spring migrants appeared in February.

Loon - Heron: **Red-throated Loon:** 7 Dec (1) Cherokee L. (KDE); 8-9 Feb (1) Chick. L. (KAC, RJH, Dan Jacobson). **Common Loon:** 20 Dec (34) Chatt CBC, max; 19 Feb (14) Cherokee L. (RLK). **Horned Grebe:** 8 Dec (26) Chick. L. (KAC), max. **Double-crested Cormorant:** 11+ all season at Kpt. (RLK, JWC); 1 Jan (121) Hiwassee CBC, max. **Great Blue Heron:** 19 Feb (50+, many standing on nests) Cherokee L., island at River Mile 65.4 (RLK). **Great Egret:** 27 Dec (1) Hiwassee, Bradley Co. portion (R&DS); 8 Dec, 20-21 Jan (1) Cherokee Dam (KDE *et al.*); 4 Jan (1) Knox CBC (KTOS). **Black-crowned Night-Heron:** up to 21 present all season at Kpt. (JWC, RLK); 20 Jan (6) Cherokee Dam (KDE).

Waterfowl: **Tundra Swan:** 17 Jan (1) Greene Co. (ACL, DHM). **Greater White-fronted Goose:** 15 Dec (1) Ktn. Stm. Pl. (KTOS); 19 Jan (1) Hmlt.

Co. (KAC). **Snow Goose:** 15 Dec (1 white) Ktn. Stm. Pl. (KTOS); 25 Jan - 10 Feb (1 blue) Bledsoe Co. (R&DS *et al.*). **ROSS' GOOSE:** 18 Jan (1) Hiwassee (RJH), second regional record. **Green-winged Teal:** 31 Jan (79) Greene Co. (ACL, DHM), max. **American Black Duck:** 1 Jan (725) Hiwassee CBC, max. **Northern Pintail:** 1 Jan (18) Hiwassee CBC, max. **Gadwall:** 3 Jan (360) Nickajack CBC, max; 11 Jan (152) Kpt. (RLK); 31 Jan (127) Greene Co. (ACL, DHM); good numbers in northeast areas. **American Wigeon:** 1 Jan (26) Hiwassee CBC, max. **Redhead:** 19 Feb (12) Cherokee L. (RLK), max. **Ring-necked Duck:** 11 Jan (126) Kpt. (RLK), max. **Greater Scaup:** 8 Dec (37) Chick. L. (KAC), max; 29 Dec (1) Wash. Co. farm pond (RLK); 3-10 all season at Kpt. (RLK *et al.*). **Lesser Scaup:** 11 Jan (45) Kpt. (RLK), max. **Oldsquaw:** 25 Jan - 10 Feb (1 f) Bledsoe Co. (R&DS *et al.*). **Black Scoter:** 20 Dec (4) Chick. L. on Chatt CBC (Danny Gaddy, Carla Christensen); 21 Dec thru Feb (1 f, joined by a second f from 8 Feb) Chick. L. at dam (m.ob.). **Common Goldeneye:** 20 Dec (45) Chatt. CBC, max. **Bufflehead:** 3 Jan (43) Nickajack CBC, max. **Hooded Merganser:** 1 Jan (53) Hiwassee CBC; 3 Jan (120) Ktn Stm Pl (JDJ), max. **Red-breasted Merganser:** 19 Feb (6) Cherokee L. (RLK), max. **Ruddy Duck:** 3 Jan (62) Nickajack CBC, max.

Vulture - Hummingbird: **Black Vulture:** 21 Jan (250 at roost) Cherokee dam (JWC, RLK, AWJ, Christy Sarver). **Osprey:** 7 Dec, 20-21 Jan (1) Cherokee Dam (KDE *et al.*). **Bald Eagle:** 7 Dec (2) Cherokee dam (KDE); 8 Feb (1 im) Holston Army Ammunition Plant, Hawkins Co. (FJA *et al.*). **Northern Harrier:** 20 Dec (15) Mohawk, Greene Co. (ACL, DHM), max., at newly acquired state-owned wetland. **Rough-legged Hawk:** 25 Jan / 9 Feb (1 light morph) Bledsoe Co. (R&DS / KAC); 31 Jan - 24 Feb (1 dark morph) Bledsoe Co. (Dan Jacobson, RJH, *et al.*). **Golden Eagle:** 31 Jan (1 im) Bledsoe Co. (R&DS). **Peregrine Falcon:** 1 ad remained thru season at Chatt nest site (Harold Sharp); 12 Dec - 1 Feb (1) downtown Knox (JDJ, AWJ, CJW). **Sora:** 25 Jan (1) Ktn. Stm. Pl. (AWJ, Audrey Mayer). **Sandhill Crane:** 30 Dec (24 flying over) Jefferson City (KDE); 1 Jan (6361) Hiwassee CBC. **Greater Yellowlegs:** 19 Feb (1) Cherokee L., Grainger Co. portion (RLK), probably an early migrant. **Least Sandpiper:** 1 Jan (12) Hiwassee CBC, max wintering there. **Dunlin:** 20 Dec, 19 Jan (1) Chick. L. (KAC); 25 Jan (1) Ktn. Stm. Pl. (AWJ, Audrey Mayer). **Common Snipe:** 1 Jan (61) Hiwassee CBC, max. **RED PHALAROPE:** 16 Feb (1) Brainerd Levee, Hmlt. Co. (KAC *et al.*). **Bonaparte's Gull:** 8/13 Dec (600 / 2000) Cherokee L. (KDE), max. **Ring-billed Gull:** 19 Feb (10,000) Cherokee L. (RLK), max. **Herring Gull:** 20 Dec (19) Chatt CBC, max. **Eurasian Collared-Dove:** 20 Dec / 24 Feb (3-2) Chatt (KAC); 9 Feb (1) Bledsoe Co. (KAC), first there. **Short-eared Owl:** 7 Dec (1) Mohawk, Greene Co. (DHM, Clyde Kessler), at new state-owned wetland. **Common Nighthawk:** 9 Dec (2), 17 Jan (1) Knox (CJW), last of lingering birds. **ALLEN'S HUMMINGBIRD:** see fall report; 26

Dec (1 ad m, banded and photographed) Bristol, VA, just a couple miles north of the state line (JWC, Van Remsen, RPL, RLK; band courtesey RRS), present several weeks total (m.ob.), first VA record and third record in southwest Appalachian Mtns. this winter.

Passerines: **Horned Lark:** 1 Jan (75) Greene Co. (ACL, DHM); 15 Feb (55) Wash. Co. (RLK). **Tree Swallow:** 15 Feb (1 / 1) Fort Loudoun SP, Monroe Co. / Kyker Bottoms, Blount Co. (KTOS); 24 Feb (1) Brainerd Levee, Hmlt. Co. (KAC); very early migrants. **Red-breasted Nuthatch:** widespread in small numbers, max 34 on Norris CBC on 20 Dec (KTOS). **Brown-headed Nuthatch:** 20 Dec (35) Chatt CBC, max. **House Wren:** 20 Dec (4) Chatt CBC; 3 Jan (1) Greeneville CBC (RLK); 15 Feb (1) Fort Loudoun SP, Monroe Co. (KTOS). **Marsh Wren:** 20 Dec (1) Chatt CBC (KAC); 1 Jan (1) Hiwassee CBC (RJH). **Gray Catbird:** 4 Jan (1) Knox CBC (KTOS). **Loggerhead Shrike:** only 4 reports in Sullivan / Wash. Cos. (RLK *et al.*); 11 reports in Greene Co. (ACL, DHM). **White-eyed Vireo:** 3 Jan (1) Nickajack CBC. **Blue-headed Vireo:** 20 Dec (1) Chatt CBC; 1 Jan (1) Hiwassee CBC. **Orange-crowned Warbler:** 20 Dec (1) Chatt CBC; 1 Feb (1) Wash. Co. (RLK). **Pine Warbler:** 19 Dec - 1 Jan (1) Oak Ridge, Anderson Co (JDJ); 4 Jan (1) Knox CBC (KTOS); 19 Feb (1) Cherokee Dam (RLK). **Palm Warbler:** 8 Dec (4) Hawkins Co. (FJA *et al.*); 20 Dec (2) Chatt CBC; 20 Dec (2) Norris CBC (KTOS); 4 Jan (1) Knox CBC (KTOS). **Black-and-white Warbler**: 4 Jan (1) Knox CBC (KTOS). **American Tree Sparrow:** 23 Dec (1) Big South Fork, Scott Co. (SJS *). **Chipping Sparrow:** 25 Dec / 18 Jan (12) Greene Co. (ACL, DHM); 4 Jan (70) Knox CBC (KTOS), unusually high number in winter. **Purple Finch:** very sparsely scattered. **Pine Siskin:** small flocks, mainly in the Chatt and Norris areas. **Evening Grosbeak:** present mainly in the Chatt area, especially on Walden Ridge; 12 Dec (67) Bledsoe Co. (R&DS), max.

Locations: Chatt - Chattanooga; Cherokee Dam - in Grainger & Jefferson Cos.; Cherokee L. - in Grainger, Jefferson & Hamblen Cos.; Chick. L. - Chickamauga L., Hamilton Co.; Hiwassee - Hiwassee River area, primarily Meigs Co.; Hmlt. Co. - Hamilton Co.; Ktn. Stm. Pl. - Kingston Steam Plant, Roane Co.; Kpt. - Kingsport; Nickajack - in Marion Co.; Wash. Co. - Washington Co.

RICHARD L. KNIGHT, 804 North Hills Drive, Johnson City, TN 37604.

EASTERN MOUNTAIN REGION: Precipitation and temperatures were above normal. There were no lowland sub-zero temperatures and very few single digit temperatures. A very wet, heavy snow of 12 to 20 inches hit northeast Tennessee in late January. This snow stripped many limbs from evergreen trees and crushed herbaceous vegetation flat. Even multiflora rose was totally flattened. This greatly reduced the cover for wintering birds. Wild fruits appeared to be in shorter supply.

Waterfowl numbers were about normal. Sparrow flocks were generally smaller. Purple Finch numbers were down, but fair numbers of Pine Siskins and Evening Grosbeaks were reported.

Loon - Owl: **Red-throated Loon:** 20 Dec (1) Watauga L. (GOW, BKS), Eliz. CBC. **Horned Grebe:** 13 Dec - 18 Jan (21-10) Watauga L. (RLK *et al.*). **Eared Grebe:** thru period (up to 20) S. Hol. L. (JWC *et al.*). **Wood Duck:** thru at least 10 Jan (1) Wilbur L. (AJT, RLK); 5-7 all season at Erwin (BKS). **Green-winged Teal:** 4 all season at Erwin (BKS). **Northern Shoveler:** 15 Feb (10) Chota, Monroe Co. (KTOS). **Gadwall:** 25 Jan (15) Bristol Industrial Park pond, Sullivan Co. (JWC). **American Wigeon:** 21 Dec (112) weir below S. Hol. L. (JWC), max. **Redhead:** 25 Jan (1) weir below S. Hol. L. (JWC). **Ring-necked Duck:** 21 Dec (48) weir below S. Hol. L. (JWC). **Greater Scaup:** 10 Feb (1) Wilbur L. (FJA, BKS). **Common Goldeneye:** 12 Dec (1) S. Hol. L. (Larry McDaniel, Janet Brown). **Bufflehead:** 21 Dec (325) weir below S. Hol. L. (JWC), second highest NE Tenn. count; 10 Jan (112) Wilbur L. (RLK). **Red-shouldered Hawk:** 27 Dec (2) Shady V. CBC. **Bald Eagle:** 10 Jan (1 ad) Watauga L. (RLK *et al.*). **Common Snipe:** 5-15 all season along Watauga R., Carter Co. (RLK *et al.*). **Great Horned Owl:** 25 Feb (1 ad) Bee Cliff, Carter Co. (RLK), at traditional nest ledge.

Swallow - Grosbeak: **Tree Swallow:** 26 Feb (1) Unicoi Co. (FJA), record early in NE Tenn. by about a week. **Red-breasted Nuthatch:** widespread in small numbers. **House Wren:** 20 Dec (1) Eliz. CBC (RLK). **Golden-crowned** and **Ruby-crowned Kinglet:** relatively low numbers all season for both. **American Robin:** scarce in Dec & Jan, with an influx in Feb. **Cedar Waxwing:** scarce. **American Pipit:** 12-14 Dec (12) Shady V. (JLS). **Blue-headed Vireo:** 28 Dec (1) Cherokee Trail, Great Smoky Mtns. N.P. CBC (DJT); 28 Dec (1) S. Hol. L., Bristol CBC (Rob Biller *et al.*). **White-eyed Vireo:** 20 Dec (1) Eliz. CBC (AJT), third local winter record. **Fox Sparrow:** 7 Dec (2) Roan Mtn (Tom Laughlin). **Red-winged Blackbird:** 23 Feb (1) Roan Mtn (AJT). **Brewer's Blackbird:** 28 Dec (1 m) S. Hol. L. (RPL *). **Purple Finch:** thru period (max 10) Holston Valley, Sullivan Co. (RPL), few other reports. **Red Crosbill:** 27 Dec (25) Shady V. CBC (Tom Laughlin). **Pine Siskin:** 20 Dec (10) Butler, Johnson Co. (GOW, BKS), Eliz. CBC; 23 Feb (50-70) Roan Mtn (AJT), max. **Evening Grosbeak:** 12 Dec (12) Shady V. (JLS); 21 Dec - 23 Feb (30-100) Roan Mtn (GOW, BKS, AJT *et al.*); 28 Dec (151) Great Smoky Mtns. N.P. CBC (Bosyd Sharp).

Locations: Eliz. - Elizabethton, Carter Co.; Erwin - in Unicoi Co.; Knox – Knoxville; Roan Mtn - in Carter Co.; Shady V. - Shady Valley, Johnson Co.; S. Hol. L. - South Holston Lake, Sullivan Co.; Watauga L. - in Carter & Johnson Cos.; Wilbur L. - in Carter Co.

RICHARD P. LEWIS, 407 V. I. Ranch Road, Bristol, TN 37620.

FJA - Fred J. Alsop
MLB - Michael L. Bierly
CHB - Carolyn H. Bullock
KAC - Kevin A. Calhoon
PDC - Phillip D. Casteel
JWC - J. Wallace Coffey
LCC - Lula C. Coffey
WGC - William G. Criswell
KDE - K. Dean Edwards
GKE - Ginger K. Ensor
FCF - Francis C. Fekel
SCF - Sue C. Ferguson
GAF - Gilbert A. Foster
MAG - Mark A. Greene
MaH - Martha Heineman
RJH - R. John Henderson
GLI - Ginger L. Ilardi
RLI - Robert L. Ilardi
AWJ - Andrew W. Jones
JDJ - J. Dev Joslin
RLK - Richard L. Knight
RPL - Richard P. Lewis
ACL - Alice C. Loftin
MLM - Margaret L. Mann
SRM - Sara R. McBride
SNM - Susan N. McWhirter
DHM - Don H. Miller
WRP - William R. Peeples
GCP - Gaynell C. Perry
DDP - Dick D. Preston
BFP - Barbara F. Priddy
FCP - Forrest C. Priddy
VBR - Virginia B. Reynolds
MBS - Martha B. Sargent
RRS - Robert R. Sargent
JeS - Jeanece Seals
R&DS - Roi & Debbie Shannon
JLS - John L. Shumate
CAS - Chris A. Sloan
BHS - Barbara H. Stedman
SJS - Stephen J. Stedman
BKS - Bryan K. Stevens
AJT - Allan J. Trently
DJT - David J. Trently
MGW - Martha G. Waldron
GOW - Gary O. Wallace
CJW- Chris J. Welsh
BHW - Barbara H. Wilson
JRW - Jeff R. Wilson
TJW - Terry J. Witt
OKM - O. Knox Martin
KTOS - Knoxville chapter, TOS
MTOS - Memphis chapter, TOS
NTOS - Nashville chapter, TOS
TOS - Tennessee Ornithological Society

INSTRUCTIONS TO AUTHORS

The Migrant records observations and studies of birds in Tennessee and adjacent areas. Most articles are written by members of the Tennessee Ornithological Society.

SUBMISSIONS: The original and two copies of the manuscript should be sent to the Editor: J.D. Joslin, 112 Newcrest Lane, Oak Ridge, TN 37830. Manuscripts that have been published in other journals should not be submitted. Electronic copies, on disk or sent by e-mail to <jdjoslin@esper.com> are greatly appreciated.

MATERIAL: The subject matter should relate to some phase of Tennessee ornithology. It should be original, factual, concise, and scientifically accurate.

STYLE: Both articles and short notes are solicited; recent issues of *The Migrant* should be used as a guide in the preparation of manuscripts. Where more detail is needed, reference should be made to the *CBE Style Manual*; this book is available at many public libraries and from the Council of Biology Editors, Inc., 111 East Wacker Drive, Suite 3200, Chicago, IL 60601-4298.

COPY: Manuscripts should be formatted with *double space* on 8.5 x 11" paper with adequate margins for editorial notations. Table should be prepared on separate sheets with appropriate title and column headings. Photographs intended for reproduction should be sharp with good contrast on glossy while paper, black-and-white photographs will usually reproduce better than color photographs. Weights, measurements, and distances should be in metric units. Dates should be in "continental" form (e.g., 16 March 1999), Use the 24-hour clock (e.g., 0500 or 1900).

NOMENCLATURE: The scientific name of a species should be given after the firs use of the full common name in the text. The scientific name should be underlined and in parentheses. Names should follow the *A.O.U. Check-list of North American Birds* (sixth edition, 1983, or supplements).

TITLE: The title should be concise, specific, and descriptive.

ABSTRACT: Manuscripts of five or more typed pages should include an abstract. The abstract should be less than 5 percent of the length of the manuscript. It should include a brief explanation of why the research was done, the major results, and why the result are important.

LITERATURE CITED: List all literature citations in a "Literature Cited" section at the end of the text. Text citations should include the author and the year.

IDENTIFICATION: Manuscripts including reports of rare or unusual species or of species at atypical times should include: date and time, light and weather conditions, exact location, habitat, optical equipment, distance, behavior of bird, comparison with other similar species, characteristic markings, experience of observer, other observers verifying the identification, and reference works consulted.

REPRINTS: Reprints are available to authors on request. Billing to authors will be through the TOS Treasurer.

SEASON REPORTS: Observations that are to be considered for publication in "The Season" section should be mailed to the appropriate Regional Compiler. Consult a recent issue of *The Migrant* for the name and address of the compilers.

CONTENTS

REPRODUCTIVE BIOLOGY OF CAROLINA CHICKADEES
T. David Pitts 69

THE SEASON: WINTER: 1 DECEMBER 1997-28 FEBRUARY 1998
Richard L. Knight 105

WESTERN COASTAL PLAIN REGION
Martha G. Waldron 106

HIGHLAND RIM AND BASIN REGION
Francis C. Fekel 108

CUMBERLAND PLATEAU/RIDGE AND VALLEY REGION
Richard L. Knight 110

EASTERN MOUNTAIN REGION
Richard P. Lewis 112

OBSERVERS 114